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On November 2-4, 1999, the U.S. Geological Survey held BioGeo99 to provide a forum in which USGS scientists, other agencies, universities, and the private sector could meet to share information in the area of applying geospatial technologies to the biological sciences. The format for the symposium included guest speakers, panel discussions, plenary sessions, oral and poster presentations, and workshops on a wide range of topics, including the use and application of Global Positioning System (GPS), aquatic and terrestrial telemetry, national classification systems, remote sensing, metadata, and other geospatial technologies used in biological science applications. After the meeting abstracts were extended by the presenters to more fully explain what was presented and detail how geospatial technologies enhance scientific research, management of biological resources, and partnerships between government and private industry.

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Edited by

Lawrence R. Handley, Frank J. D'Erchia, and Tammy M. Charron

Information and Technology Report
USGS/BRD/ITR–2000-0008

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
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2:00 p.m. - 4:00 p.m. "Town Hall Meeting" with Larry Ludke, Regional Chief Biologist, USGS, Central Region
3:00 p.m. - 5:00 p.m. Registration
4:00 p.m. - 5:00 p.m. Tours of the NWRC remote sensing and GIS facilities
4:30 p.m. - 6:00 p.m. Geospatial Technology Program Council meeting, NWRC Conference Room

NOVEMBER 2, 1999 - Cajun Dome Ballroom

7:30 a.m. - 2:00 p.m. Registration
8:15 a.m. Welcome - Bob Stewart, Center Director, USGS, NWRC
8:30 a.m. Opening remarks - Larry Ludke, Regional Chief Biologist, USGS, Central Region
"Gateway to the Earth" - Gladys Cotter, Associate Chief Biologist for Information, USGS
"Significance of Integrated Geospatial Technology to Biological Science" - Tom Casadevall, Deputy Director, USGS
10:00 a.m. Break
10:30 a.m. **Plenary Session - Telemetry**
Moderator - Mike Parsley, USGS, Western Fisheries Research Center
10:45 a.m. **Plenary Presentations - Telemetry**
"Telemetry Applications at the U.S. Geological Survey's Alaska Biological Science Center" - Dave Douglas, USGS, Alaska Biological Science Center
"Telemetry in the Aquatic Environment: Where We Are and Where We're Headed" - John Beeman, USGS, Western Fisheries Research Center
11:30 a.m. Lunch
1:00 p.m. - 2:30 p.m. **Paper Session I - Topics on Wildlife Tracking**
Moderator - Mike Parsley, USGS, Western Fisheries Research Center
"Radio-Tracking Large Wilderness Mammals: Integration of Global Positioning System and Argos Technology" - Charles Schwartz, USGS, Midcontinent Ecological Science Center
"Pallid Sturgeon Habitat Identification, Use, and Characterization: Integrating Telemetry and Underwater Remote Sensing Data in the Lower Missouri River" - Aaron DeLonay, USGS, Columbia Environmental Research Center
"Linking Telemetry Locations with Habitat Use and Availability" - Clint Jeske, USGS, NWRC
Concurrent Workshops
Moderator - John Young, USGS, Leetown Science Center
1:00 p.m. Global Positioning System Workshop - Karl Brown, USGS, Center for Biological Informatics
3:00 p.m. - 4:00 p.m. Department of the Interior Narrowbanding Issues Workshop - Wayne Wiltz, USGS, NWRC
2:30 p.m. Break
2:45 p.m. - 4:30 p.m. **Paper Session II - Topics on Habitat Modeling**
Moderator - Linda Leake, USGS, Upper Midwest Environmental Sciences Center
"Validation of a Geographic Information System Coverage of Potential Breeding Bird Distribution on the Upper Mississippi River" - Eileen Kirsch, USGS, Upper Midwest Environmental Science Center
"Modeling the Distribution of Neotropical Birds Throughout the Americas" - Ian Thomas, APL Inc., USGS, Patuxent Wildlife Research Center
"Modeling Hurricane Dynamics and Distribution of North Atlantic Tropical Storms: A Geospatial Tool for Ecological Research" - Thomas Doyle, USGS, NWRC
"Development of a Geographic Information System to Assist in the Evaluation of Waterbird Use of Flooded Agricultural Lands in the East and West Gulf Coastal Plain" - Paul C. Chadwick and Wayne Norling, USGS, NWRC
5:00 p.m. - 7:00 p.m. Reception social - interactive session for demonstrations, poster presentations, and vendor exhibits (see Contents for full list of posters)

NOVEMBER 3, 1999 - Cajun Dome Ballroom

8:30 a.m. - 12:00 a.m. Registration

8:30 a.m. Announcements

8:45 a.m. "Remote Sensing Advances and the Future" - Wayne Rohde, Deputy Director, USGS, EROS Data Center

9:15 a.m. **Panel Session - Remote Sensing**
Moderator - Ralph Root, USGS, Center for Biological Informatics
Keynote speaker - Tom Loveland, USGS, EROS Data Center, "From an Ominous Beginning to an Auspicious Future: Satellite Remote Sensing in the 21st Century"

9:45 a.m. Break

10:00 a.m. **Panel Presentations - Remote Sensing**
"Possibilities and Pitfalls in the Use of Remote Sensed Data for Mapping and Characterizing a Dynamic Landscape" - Tom Loveland, USGS, EROS Data Center
"Status of the Commercial One-Meter Satellite Data" - Bruce Davis, NASA, John C. Stennis Space Center
"Radar Data for Vegetation Mapping" - Jon Ranson, NASA, Goddard Space Flight Center
"Hyperspectral Imaging" - Elijah Ramsey III, USGS, NWRC

11:00 a.m. Open discussion with panel

11:30 a.m. Lunch

1:00 p.m. **Plenary Session - National Vegetation Classification Standard Applications**
Moderator - Tom Owens, USGS, Center for Biological Informatics

1:15 p.m. - 2:15 p.m. **Plenary Presentations - National Vegetation Classification Standard**
"The National Vegetation Classification Standard: Background and Current Status" - Denny Grossman, The Nature Conservancy
"National Vegetation Classification Standard and the U.S. Geological Survey-National Park Service Vegetation Mapping Program: A Case Study at Voyageurs National Park" - Samuel Lammie, Voyageurs National Park
"Implementing the National Vegetation Classification Standard in Mapping and Classification Vegetation Projects" - Tom Owens, USGS, Center for Biological Informatics

Concurrent Workshop
Moderator John Young, USGS, Leetown Science Center

1:00 p.m. - 3:00 p.m. Animal Movement and ArcView Tool Creation Workshop - Philip Hooge, USGS, Alaska Biological Science Center

2:15 p.m. - 3:00 p.m. **Paper Session III - Topics on Change Detection**
Moderator - Greg Kennedy, USGS, Great Lakes Science Center
"Land Use and Vegetation Changes in Nigeria: Analysis of Nigeria Environment Using Satellite Images and Geographic Information Systems" - Wilson Eedy, Terfa Inc.
"A Spatial Analysis of the Effects of Disturbance on Native Mixed-Grass Prairie Vegetation" - Brett Rubenstein and Diane Larson, USGS, Northern Prairie Wildlife Research Center

3:00 p.m. Break

3:30 p.m. - 4:15 p.m. **Paper Session III continued**
"Northeastern Gulf of Mexico Seagrass Status and Trends" - Lawrence Handley, USGS, NWRC
"Use of AVIRIS Hyperspectral Imaging for Detection and Mapping of Leafy Spurge at Theodore Roosevelt National Park" - Ralph Root, USGS, Center for Biological Informatics

6:30 - 10:00 Dinner banquet at Vermilionville
Live Cajun Music by Les Frères Michot

NOVEMBER 4, 1999 - Cajun Dome Ballroom

8:30 a.m. Announcements

8:45 a.m. "Integrating and Invigorating Biological Research with Geospatial Technologies" - Susan Haseltine, Deputy Chief Biologist for Science, USGS

9:30 Break

10:00 - 11:00 **Panel Session - Gap Analysis Program Applications**
Moderator - Dan Petit, USGS, National Center

Panel Presentations - GAP

"The Gap Analysis Program: An Update on Status, Implementation, and Decision Support Systems" - Patrick Crist, USGS, Idaho Coop Unit

"A Gap Approach to Modeling Biodiversity " - Kimberly Smith, University of Arkansas, Fayetteville

"Enhancing Natural Resource Management and Biodiversity Protection with Gap Analysis Data" - Richard Minnis, Mississippi State University, Mississippi Cooperative Fish and Wildlife Research Unit

11:00 a.m. Open discussion with panel

11:30 a.m. Lunch

1:00 p.m. "Geographic Information Systems in the Courtroom for Natural Resource Litigation" - Andrew C. Wilson, Burke and Mayer

1:40 p.m. - 3:00 p.m. **Paper Session IV - Topics on Metadata**

Moderator - Ralph Campbell, USGS, Northern Prairie Wildlife Research Center

"Building a Transboundary National Spatial Data Infrastructure/National Biological Information Infrastructure Metadata Clearinghouse Node for the Texas-Mexico Borderlands" - Charles Palmer, Texas Water Development Board

"Metadata—The Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata Part 1: Biological Data Profile" - Susan Stitt, USGS, Center for Biological Informatics

"Metadata: Your Key to Documenting and Discovering Data" - Jennifer Gaines, USGS, Office of Biological Informatics and Outreach

"Metadata SWAT Teams: A Success Story in Creating a Regional Clearinghouse Node" - Robert Norheim, USGS, Forest and Rangeland Ecosystem Science Center

Concurrent Workshop

Moderator - John Young, USGS, Leetown Science Center

2:00 p.m. - 4:00 p.m. Satellite Telemetry Workshop - Dave Douglas, USGS, Alaska Biological Science Center

3:00 p.m. - 3:30 p.m. Break

3:30 p.m. - 4:15 p.m. **Paper Session V - Topics on Vegetation Sampling and Mapping**

Moderator - Lawrence Handley, USGS, NWRC

"A Geospatial Solution to Problems with Siting Wetland Vegetation Sampling Transects Near a Sinuous Creek in Seney National Wildlife Refuge, Michigan" - Kurt Kowalski, USGS, Great Lakes Science Center

"Remote Sensing and Geographic Information Support for Water Hyacinth Management on Lake Victoria, East Africa" - Thomas Albright and Larry Tieszen, USGS, EROS Data Center

"A New National Mosaic of State Landcover Data" - Ian Thomas, APL Inc., USGS, Patuxent Wildlife Research Center

5:00 p.m. - 6:30 p.m. Geospatial Technology Program Coordinators Meeting - NWRC Conference Room

NOVEMBER 5, 1999 - NWRC Training Room

8:00 a.m. - 12:00 a.m. National Biological Information Infrastructure/Federal Geographic Data Committee Metadata: Adding Value to Biological and Spatial Data Sets - Jennifer Gaines, USGS, Office of Biological Informatics and Outreach and George Lienkaemper,USGS, Forest and Rangeland Ecosystem Science Center

Extended Abstracts from BioGeo99: Applications of Geospatial Technology to Biological Sciences

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Nov. 2-4, 1999

Compiled and edited by

Lawrence R. Handley
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, Louisiana 70506

Frank J. D'Erchia
U.S. Geological Survey
Biological Resources Central Regional Office
Denver Federal Center
P.O. Box 25046, MS 300
Denver, CO 80225-0046

Tammy M. Charron
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, Louisiana 70506

Abstract: On November 2-4, 1999, the U.S. Geological Survey held BioGeo99 to provide a forum in which USGS scientists, other agencies, universities, and the private sector could meet to share information in the area of applying geospatial technologies to the biological sciences. The format for the symposium included guest speakers, panel discussions, plenary sessions, oral and poster presentations, and workshops on a wide range of topics, including the use and application of Global Positioning System (GPS), aquatic and terrestrial telemetry, national classification systems, remote sensing, metadata, and other geospatial technologies used in biological science applications. After the meeting, abstracts were extended by the presenters to more fully explain what was presented and detail how geospatial technologies enhance scientific research, the management of biological resources, and partnerships between government and private industry.

Keywords: geospatial, GIS, GPS, remote sensing, telemetry

Introduction

On 2-4 November 1999, the U.S. Geological Survey's (USGS) Biological Resources Division Geospatial Technology Program and National Wetlands Research Center hosted "BioGeo99: Applications of Geospatial Technology to Biological Sciences" at the Cajundome in Lafayette, Louisiana. The symposium focused on current applications of geospatial technologies that enhance scientific research and management of biological resources and provided a forum for exchange of information and ideas. This symposium was sponsored by the USGS, Biological Resources Division, Deputy Chief Biologist for Science and Associate Chief Biologist for Information. Frank D'Erchia, Associate Regional Biologist and chair of the Geospatial Technology Council for the Biological Resources Division in the Central Region, and Lawrence Handley, geographer at the National Wetlands Research Center, were the primary architects of BioGeo99.

During the past 80 years, ecologists and other scientists have built a theoretical foundation for the proximate and ultimate factors influencing the distribution, movement, life history attributes, and interactions of plants and animals, as well as the natural and human-caused environmental perturbations, processes, and changes that modify those patterns.

An understanding of these patterns and relationships is central to the conservation and management of natural resources. Until recently, scientists have been limited in their ability to test and advance these models much beyond their "first generations" because no technologies were available that could accurately measure, summarize, integrate, and display the complexities of the environmental patterns and processes they were attempting to evaluate. With recent advances in

geospatial technology, those limitations are rapidly disappearing. This symposium was designed, in part, to provide scientists who study these environmental issues with the opportunity to learn about important new geospatial technology tools.

Symposium Summary

The three-day symposium featured guest speakers, panel discussions, plenary sessions, and oral and poster presentations. Topics of discussion were of a wide range, including the use and application of the Global Positioning System (GPS), aquatic and terrestrial telemetry, national classification systems, remote sensing, metadata, and other geospatial technologies used in biological science applications. Concurrent workshops on animal tracking via satellite, animal movement analysis, GPS applications, and metadata were also presented.

Guest Speakers

November 2, 1999

Opening Remarks

Larry Ludke, USGS, Regional Chief Biologist, Central Region

Larry Ludke set the tone for the symposium in his opening remarks by discussing the prominent role geospatial technologies play in place-based and integrated approaches to science. USGS uses a multidisciplinary approach to address natural resource science issues and ecosystems of concern and will continue to apply geospatial technology solutions to these place-based problems. Geospatial technologies foster opportunities for USGS to form partnerships with other agencies and share data. Also, resource management problems can be addressed by geospatial applications, and managers are provided with information "integrators."

Significance of Integrated Geospatial Technology to Biological Science

Tom Casadevall, USGS Deputy Director

In his keynote address, Tom Casadevall explained that the USGS convened the BioGeo99 symposium to (1) provide a forum in which people could meet to share and identify gaps in information and form partnerships in the area of applying geospatial technologies to the biological sciences and to (2) further define the role of geospatial technologies for the future by providing a forum where people could learn about the work USGS scientists, other agencies, universities, and the private sector are doing.

Casadevall cautioned that we need to recognize that these technologies are expanding rapidly and that we need to pay close attention to how geospatial technologies can enhance research. A key to ensuring the effective use and application of these technologies is their successful transfer to field researchers. One of the challenges is to think beyond biological applications of geospatial technologies. All divisions and other Department of the Interior agencies use geospatial technology. We should not focus too narrowly because each group of USGS has applications that need to be grown together.

Casadevall also gave a brief overview of USGS and stated the common goal of having policy and management decisions based not simply on perceptions but on sound science. In short, integrated information is the key, and geospatial technologies allow this integration.

Gateway to the Earth

Gladys Cotter, USGS, Associate Chief Biologist

Cotter showed the presentation the USGS was using around the country to inform people about the Gateway to the Earth, which is a coherent set of interfaces that enables diverse users to find, get, and use natural science information in ways that are meaningful to them. In essence, the Gateway to the Earth provides a single point of access to information. Gateway to the Earth objectives are as follows:

- To maximize USGS $13 billion in Earth science data and information.
- To provide single point access to USGS natural science data, information, and knowledge.
- To relate USGS data and information to places and processes in, on, and around the Earth.
- To point to partners' information where appropriate.

The Gateway to the Earth is also a tool for integrating science, and the area of geospatial technologies is very important to integrating science. Cotter explained the need to start informing the public how geospatial technologies will impact the Gateway to the Earth. Geographic information systems and the Global Positioning System, for example, monitor global climate change, map land cover, track animal movements, and facilitate decision support. In fact, decision support systems are very important to policy makers and the public because they help us make good decisions.

Cotter stressed the symposium was important because it provided a place to share ideas, but that we need to broaden the group we are transferring the technology to so that it is better understood within the larger community. The National Information Infrastructure, the National Spatial Data Infrastructure, the National Biological

Information Infrastructure, and the Digital Earth are all national initiatives related to geospatial technology and are key elements of what the USGS is trying to do in the way of delivering information to diverse customers.

November 3, 1999

Remote Sensing Advances and the Future

Wayne G. Rohde, USGS, EROS Data Center

Satellite remote sensing from space began in the early 1960's with the first generation of photo reconnaissance satellites which yielded small scale panchromatic imagery. The imagery collected from these satellites was classified and not available to the science community or to the public until 1995. In 1972, the first Landsat system was successfully launched. This system, for the first time, provided near global, repetitive, medium resolution (90 m) imagery in four spectral bands, and in a digital format. In the 1980's, satellite imaging systems were launched that enabled scientists to acquire imagery in additional spectral bands in the short wave infrared and thermal portions of the electromagnetic spectrum with significant improvements in radiometric and geometric calibration, spatial resolution, stereo capabilities, and revisit times.

The 1990's has been a decade of significant change, opportunity, and challenge in the area of land imaging satellites. There has been a continued emphasis on launching new systems capable of imaging in additional spectral bands, improved radiometry and geometry, improved stereo capabilities, improved spatial resolution, and improved access to the data by the user community.

Further, these systems are now being operated by not only the U.S. government, but also by several foreign governments and international organizations, and most recently by private industry. Scientists can, in the next decade, look forward to a plethora of satellite data of the Earth's surface with technology available to efficiently exploit these new data and opportunities to address issues ranging from local or regional to global in scale. Future challenges will be many and will include determining which sensing technology is appropriate, accessing the data efficiently, ensuring adequate training and skills to fully exploit the data, and preserving these data for future scientists. The future is indeed enormous!

(The author was provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

November 4, 1999

Integrating and Invigorating Biological Research and Applications with Geospatial Technologies

Susan Haseltine, Chief Scientist Biology

Geospatial technologies offer significant opportunities for advances in both ecological research and natural resources management in the 21st century. Geospatial technologies have allowed us to quantitatively move from single species life history studies to animal community studies that are integrated with ecological drivers and changes in physical environments. They have facilitated the integrations of not only spatial change but multiple time scale changes into ecological and population analyses. But, even today, we see both resource management and research based upon single species in small areas. Visualization techniques based on geospatial technologies have assisted researchers in "thinking" ecologically, but problems and barriers remain to close collaborations. These barriers include: rapid but not complementary scientific advances in both biological sciences and geospatial technology; age and training of biological scientists, stovepiping in university training; disparate jargon; and differing values and endpoints in scientific approach between information and biological scientists. Incentives to closer working relationships include joint development of new technology applications; common customer focus; common agreement on definitions of decision support systems; and building institutional rewards for collaborations. Only with these improvements will the true potential for either ecological research or geospatial applications to change conservation and natural resource management be realized.

Geographic Information Systems in the Courtroom for Natural Resource Litigation

Andrew C. Wilson, Burke and Mayer; and John Barras, Steve Hartley, and James B. Johnston, USGS, National Wetlands Research Center

One of the fastest growing applications for geographic information systems (GIS) is in the area of litigation. The use of a GIS format in the courtroom through the medium of a computer projector allows for the rapid and effective presentation of vast quantities of highly detailed technical information in an interesting, if not entertaining, interactive format. The trier of fact, whether judge, jury, or agency official, can easily assimilate in a matter of minutes or hours what would normally be presented through reams of inanimate paper in a tedious, time-consuming process that might drag on for days, weeks, or months.

By allowing the trier of fact to quickly visualize the relevant information or evidence, courtroom attention is maintained and retention is enhanced. Further, reference can be made back to the same visual images at any time during the proceedings to re-urge or re-emphasize a particular point or fact in connection with the testimony of one or more witnesses. The presentation can also be used for opening and closing statements. The interactive component of these presentations, that is, the magnification (zooming) of graphics, the creation of new graphics through combinations of overlays, and the highlighting (with "paint brush" or otherwise) of exhibits provides a capability unique to the presentation of a GIS which cannot be duplicated through hard copy. Further, admissibility of such evidence is facilitated by the fact that most of the information is based primarily upon governmental and business records which are excepted from the barriers normally associated with the "hearsay rule."

Types of cases utilizing GIS involve class actions related to the dispersion of water pollution, noxious gases or other substances; natural resource damage or impacts; drainage and overland flow models; boundary disputes; remediation of contaminated sites; pipeline damage; geographic changes over time (aversion, devegetation, etc.); and, accident reconstructions involving large geographic areas.

As GIS technology improves and more and more governmental data and graphics become readily available, it should be anticipated that there will be no end to the potential applications in connection with litigation. Eventually, trial counsel may find themselves "outgunned" if they attempt to proceed to trial utilizing a tedious paper presentation to refute a rapid, attention-catching, interactive GIS presentation.

(The authors were provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Paper Sessions

Topics on Wildlife Tracking

Radio-Tracking Large Wilderness Mammals: Integration of Global Positioning System and Argos Technology

Charles C. Schwartz, USGS, Midcontinent Ecological Science Center

Biologists from the state of Alaska and the Interagency Grizzly Bear Study Team tested the fix success rate for 34 prototype, Global Positioning System (GPS) radio collars on brown or grizzly bears (*Ursus arctos*) over a 5-year period on the Kenai Peninsula, Alaska, and in the Greater Yellowstone ecosystem. Collars were of two design types: (1) GPS units with an Argos satellite uplink ($n = 19$) and (2) GPS units where the data were stored on board ($n = 10$) for retrieval at a later date. All units also contained a conventional VHF transmitter and weighed 1.7 kg. Global Positioning System-Argos units obtained 10% to 82% of expected GPS fixes, and fix rate declined significantly ($P < 0.05$) with time after deployment. Argos uplink success (proportion of successful transmission of stored data) was linearly related to GPS fix rate ($r = 0.91$, $P < 0.001$). Store-on-board units obtained significantly more successful fixes when compared with the GPS-Argos units ($t = -4.009$, $P < 0.001$). Fix success rate for deployed store-on-board collars ranged from 13% to 96%; because of the increased number of attempted fixes per day, these collars obtained fixes on 97% of days deployed. Accuracy of the GPS units was less than predicted by the Navstar GPS technology using the course acquisition code. Reduced accuracy was likely a result of the proportion of two-dimensional versus three-dimensional fixes obtained, although we could not determine this statistic from recorded data. Increased overstory closure was the only variable measured that partially explained the reduced likelihood of a successful fix. Stem density, stem diameter, and overstory height measured within 3 m of the collar did not affect fix success. Global Positioning System fix success rates for collars attached to bears varied more and were lower than fix rates for stationary collars placed in various vegetation types, suggesting that the bear, terrain, and movement all influence both fix and uplink success rate. Application of this new technology to grizzly or brown bear research will provide continuous relocation capability and should provide insight into movements and habitat uses not detected with conventional VHF telemetry. Our results are comparable to studies using similar technology with moose (*Alces alces*). Recent advances in technology allow for (1) differential correction, (2) improved fix rates coupled with reduced power consumption, (3) potential retrieval of data via a communication link, and (4) remote release mechanisms that permit collar drop and eliminate the need to recapture the animal.

Pallid Sturgeon Habitat Identification, Use, and Characterization: Integrating Telemetry and Underwater Remote Sensing Data in the Lower Missouri River

Aaron J. DeLonay, Edward E. Little, Mark S. Laustrup, and Robert B. Jacobson, USGS, Columbia Environmental Research Center; and Charles F. Rabeni, USGS, Missouri Cooperative Fish and Wildlife Research Unit

The pallid sturgeon (*Scaphirhynchus albus*) is an endangered species endemic to the Lower Mississippi and Missouri Rivers. Massive habitat alterations have resulted in the decline of this and other native fish species. Recovery of the pallid sturgeon is limited by a lack of information on its behavior, movement, and habitat requirements. Pallid sturgeon were surgically implanted with ultrasonic transmitters. A network of automated receivers was used to segment the Missouri River into 40-kilometer stretches to monitor passage of implanted sturgeon and to document long-range movement. Manual receivers were used to track and locate sturgeon within each river stretch. Locations were determined by using a Differential Global Positional System (DGPS), and physical habitat characteristics were recorded. An integrated habitat assessment protocol is being developed that will provide simultaneous measurements of depth, velocity, and substrate; this capability will allow us to characterize the surrounding physical habitat and identify features that may explain the distribution of implanted fish. Instrumentation includes a high-precision depth sounder, a bed-material classification instrument, and an acoustic doppler current profiler; data are georeferenced with a submeter accuracy DGPS and mapped in real time. Information from these studies will be used by resource managers to implement species recovery actions and guide habitat rehabilitation efforts.

(The authors were provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Linking Telemetry Locations with Habitat Use and Availability

Clinton W. Jeske, Paul Chadwick, and Wayne Norling, USGS, National Wetlands Research Center

We instrumented female northern pintails (*Anas acuta*) in central Louisiana to determine movement patterns and habitat use in 1993, 1994, and 1995. Northern pintails use several wetland types but are most abundant in large, shallowly flooded (9-25 cm) areas with little emergent vegetation. They are abundant in the rice prairies and river deltas of Louisiana, Arkansas, and Texas. Because the instrumented birds moved extensively through Louisiana and Arkansas, we had to aerially locate birds weekly. Locations were determined with an average ground accuracy of 5 ha. To assess pintail response to changes in habitat availability in the study area, we attempted to use rainfall as an index to wetland conditions. We hypothesized that pintails would be moving in response to rainfall. The analyses indicated that female pintails dispersed from Catahoula Lake, Louisiana, in three general patterns, based upon wetland conditions. Timing of movements coincided with periods of precipitation or disturbance, primarily hunting. Pintails which arrived at Catahoula Lake in October and November remained in the agricultural areas of Louisiana and Arkansas, with very limited movements to the coastal marshes or movement westward into the agricultural areas of Texas. Northward movements into Arkansas occurred any time substantial rainfall occurred in the agricultural regions, and northward movements generally stopped at the frostline. No differences in adult or juvenile female movement patterns were apparent. Now that we have information on how pintails move during the winter in the Mississippi Flyway, the question is how can this information be used to manage pintails? Questions regarding appropriate distribution, size, and wetland habitat types can be addressed with this information. For example, development of refuges outside the main activity areas of instrumented pintails would be of little use because it is unlikely the birds would use these areas. Because of increased hunter harvest in wet winters, which dispersed the birds more, a widely distributed pattern of management units may similarly increase harvest.

Topics on Habitat Modeling

Validation of a Geographic Information System Coverage of Potential Breeding Bird Distribution on the Upper Mississippi River

Eileen Kirsch, USGS, Upper Midwest Environmental Sciences Center

Biologists and managers along the Upper Mississippi River System (UMRS) indicated a need for spatial animal-habitat models to help them make decisions. In 1993 we developed two types of geographic information system (GIS) habitat models for birds on the UMRS. The first used detailed data from literature searches and expert opinion to predict potential habitats used by 17 bird species throughout their annual cycle in UMRS Pools 8 and 19. The second model, developed with the help of a committee of wildlife biologists, was based on a two-dimensional matrix of bird presence and 13 cover classes used in the UMRS GIS and can be used to build spatial models for any pool. In 1994, a study was initiated by scientists at the Upper Midwest Environmental Sciences Center to systematically collect bird and habitat data at several UMRS pools to validate, refine, and create models. Our detailed and general models were validated by using bird survey data, focusing on several bird species in different habitats. In general, both the simple and detailed a priori models performed well, and the majority of errors favored the resource. Rates of omission error did not favor the resource.

(The author was provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Modeling the Distribution of Neotropical BirdsThroughout the Americas

Ian Thomas, APL Inc., Patuxent Wildlife Research Center

I assessed the geographic information system (GIS) model and data layers used to create individual Neotropical bird species distribution maps from habitat data contained in the Ecological and Distributional Databases in "Neotropical Birds: Ecology and Conservation" by D.F. Stotz, J.W. Fitzpatrick, T.A. Parker III, and D.K. Moskovits.

(The author was provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Modeling Hurricane Dynamics and Distribution of North Atlantic Tropical Storms: A Geospatial Tool for Ecological Research

Thomas W. Doyle, USGS, National Wetlands Research Center; and Garrett Girod and Darren Johnson, Johnson Controls World Services Inc., National Wetlands Research Center

Hurricanes are episodic climatic events of formidable force and destruction to both municipalities and natural areas. The regularity and severity of tropical storms are major determinants controlling ecosystem structure and succession for coastal forests worldwide. Long-term monitoring of hurricane impacts and ecosystem recovery is needed to understand how some coastal systems adapt and respond to large-scale disturbance phenomenon. Site-specific meteorological data of hurricane wind speeds and direction, however, are only available for select populated cities located inland from the coast. A research tool was needed to provide predicted wind and surge conditions of remote field sites and conservation areas and to facilitate investigations of hurricane impact and recovery of natural systems. A spatial simulation model of hurricane abiotics, HURASIM, was developed to reconstruct chronologies of hurricane windforce and vectors for remote locations derived from historic tracking data of North Atlantic tropical storms. The model estimates a suite of storm characteristics (i.e., quadrant, windspeed, and direction) within discrete spatial units and time intervals specified by the user for designated storms, years, and study site locations. HURASIM recreates hurricane structure and circulation based on a tangential wind function, inflow angle offset, forward speed, and radius of maximum winds. Data input for the model includes tracking information of storm position, or latitude and longitude, every 6 h or less and maximum sustained wind speed. The model offers a suite of mathematical functions and parameter sets for the tangential wind profile published from other hurricane studies. Model output is user-specified for point or area applications. Point applications involve a predetermined site location given in latitude and longitude. Area applications constitute a landscape matrix of defined geographic boundaries and resolution. Storm path and trajectory is interpolated on an hourly basis or fraction thereof. Profiles of estimated wind conditions for a given site application are stored by year and storm. Case examples are given of HURASIM model output correlated with ground and mapped field data of hurricane impact from Hurricanes Camille, Andrew, and other significant storms. Algorithms have been developed from model output and field observations that predict the degree of structural damage and tree mortality by site and species for modeling hurricanes effects on coastal ecosystems. Empirical relationships drawn from this work have been incorporated into simulation models of forest growth and succession for mangrove, pine flatwood, and bottomland hardwood systems of the gulf coast region.

Development of a Geographic Information System to Assist in the Evaluation of Waterbird Use of Flooded Agricultural Lands in the East and West Gulf Coastal Plain

Paul C. Chadwick and Wayne Norling, USGS, National Wetlands Research Center

To help evaluate waterbird survey data of rice fields in the East and West Gulf Coastal Plain, a geographic information system (GIS) was developed to provide spatial analysis support. A major problem facing USGS biologists collecting waterbird data from this area was to accurately quantify rice field habitat on 31 roadside transects in southwestern Louisiana and 19 survey transects in southeastern Texas. Louisiana transects consisted of a total of 439 fields with an average of 14 fields per transect, and Texas transects contained a total of 290 fields with an average of 15 fields per transect. Obtaining field area (m^2) estimates using corrected Global Positioning System (GPS) locations for each transect field was ruled out because of the large number of fields involved in the study, and obtaining permission to access fields from that many landowners seemed unlikely. Some field sizes were available from county Natural Resources Conservation Service (NRCS) offices, but many of the area (m^2) estimates listed on the aerial photos used by NRCS were for fields that had been grouped according to landowner. Additionally, area (m^2) estimates were not available from NRCS aerial photos for

the portion of the fields that were actually surveyed; transect fields were sampled for their entire length parallel to the selected road to a depth of 200m. To derive accurate area (m^2) estimates, 1-m color infrared digital orthophoto quarter-quadrangles (DOQQs) were used as a backdrop in ArcView 3.1 on which "field" polygon themes were created to obtain the area (m^2) of each transect field. To obtain the sampled area (m^2) of each field, a "transect" polygon which encompassed the transect road, ditches on either side of the road, and the remaining area up to the roadside levee was created. The Xtools extension was then used to buffer the transect polygon by 200m to represent the 200m section of each field actually surveyed. This "buffer" polygon theme was then used to clip the field polygon theme to obtain a "sample" polygon theme, which is the area (m^2) for each transect field actually surveyed. Future GIS capabilities will incorporate habitat and species data so that complex spatial queries can be made, such as identifying fields, transects, or counties with the greatest waterbird abundance in the East and West Gulf Coastal Plain. Future GIS will also be able to evaluate species composition and abundance in relation to different habitat variables.

Topics on Change Detection

Land Use and Vegetation Changes in Nigeria: Analysis of Nigeria Environment Using Satellite Images and Geographic Information Systems

Wilson Eedy, Terfa Inc.

Satellite images (SPOT, JERS-1, LANDSAT, and ERS-1) flown between 1976-78 and 1993-95 were selected to give complete coverage of all of Nigeria for each of these periods and to allow the analysis of change over this period of time. Images were analyzed at 1:150,000 scale and mapped at 1:250,000 using EASI/PACE and ARC/INFO. Groundtruthing occurred in all habitat types and existing land-use regions. A follow-up study was conducted in 1997-98 using RADARSAT, and further field work was done in 1995-99 to map forest reserves of Nigeria in more detail. Existing environmental, geological, socioeconomic, and land-use data were also collected and digitized. Maps and digital information are available through our Web site at http://www.geoniger.com. This paper presented a summary of some of the more obvious environmental changes which were documented through satellite analysis. These changes included agricultural expansion, desertification, urban expansion, loss of forest and wetlands, and coastal loss. Each of these was discussed in terms of the usefulness of satellite and geographic information systems (GIS) analysis and in terms of further research needs.

These studies were the first of their nature in 20 years, thus presenting both an update in satellite technology and documentation of a lengthy period of environmental change. The major changes in land use and vegetation included:

- a southward migration of the borders of dry (savanna) ecozones;
- loss of some areas of critical ecological habitat (Lake Chad);
- areas of significant coastal erosion (Niger delta);
- 13.2% increase in agricultural cropland;
- 12.6% increase in grazing lands;
- 161.4 % increase in major urban lands;
- 572% increase in irrigation projects;
- 395% increase in areas of sand dunes (desertification);
- 58.3% increase in dry grasslands (Sahel Savanna);
- 46.2% loss of treed grassland (Guinea Savanna);
- 53.3% loss of undisturbed forest;
- 28.2% loss of shrub-grassland (Sudan Savanna); and
- 45.3% loss of wetlands.

A more detailed paper as well as related literature are available from the author.

A Spatial Analysis of the Effects of Disturbance on Native Mixed-Grass Prairie Vegetation

Brett Rubenstein and Diane Larson, USGS, Northern Prairie Wildlife Research Center

Disturbance is generally considered to favor the invasion of alien plants into native vegetation. However, disturbance can take many forms, not all of which may be equally detrimental. At Theodore Roosevelt National Park, North Dakota, we identified three distinct types of disturbance: prairie dog activity (a "natural" disturbance), roads, and trails (anthropogenic disturbances). Our objective was to determine if these different disturbances affect the native plant communities at the park in different ways. We combined existing georeferenced data for vegetation types, roads, and trails with a stratified random sample of 1,314 vegetation transects throughout the park and compared community characteristics and exotic plant dominance within 0 - 100 m and 100 - 200 m of roads, trails, and prairie dog towns. Our analysis suggests that although vegetation on prairie dog towns is significantly different from undisturbed prairie, the differences do not persist as far from the disturbance as do differences associated with roads. The number of alien plant species was highest on transects associated with both roads and dog towns. Vegetation associated with trails did not differ from undisturbed prairie in terms of number of alien plant species.

Northeastern Gulf of Mexico Seagrass Status and Trends

Lawrence R. Handley and Arturo Calix, USGS, National Wetlands Research Center; and Eric Seeger, Rosemary Mouton, and Jesse Thibodeaux II, Johnson Controls World Services Inc., National Wetlands Research Center

The U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) funded the National Wetlands Research Center (NWRC) of the U.S. Geological Survey (USGS) to map from aerial photography all the seagrasses for the Louisianian Province (Brownsville, Texas, to Anclote Key, Florida). This mapping effort established the total seagrass inventory from which samples could be taken. Due to funding constraints, EMAP was able to fund only the first 2 years of the proposed 5-year mapping effort. In the 2 years, 1992 and 1993, natural color aerial photography was collected for the area from the Chandeleur Islands, Louisiana, to Anclote Key, Florida, and mapping was completed for the area from the Chandeleur Islands to St. Joe Bay, Florida. In 1996, the Florida Department of Environmental Protection funded the NWRC to complete the mapping of seagrasses for the area from Cape San Blas, Florida, to Anclote Key, Florida.

Consequently, the NWRC has completed the mapping of the distribution of seagrass habitat in the northeastern Gulf of Mexico as a baseline inventory. This project encompassed 149 USGS 1:24,000 scale quadrangles covering over 2,000 miles of shoreline from the Chandeleur Islands to Anclote Key (over 9,000 square miles). The mapping was based on 1992 natural color 1:24,000 scale aerial photography and followed a standardized mapping protocol and classification system. Approximately 950,000 acres of seagrasses were inventoried in the project. This seagrass mapping effort was an important baseline information component for comprehensive estuarine resource assessment. In addition, the project could not have been accomplished without the active participation of several federal, state, and public entities for groundtruthing and peer review, including EMAP, the Minerals Management Service's Gulf of Mexico Region, the Florida Department of Environmental Protection's Florida Marine Research Institute, U.S. Fish and Wildlife Service's Panama City Ecological Services Office, the National Park Service's Gulf Island National Seashore, the University of South Alabama's Dauphin Island Sea Lab, the National Marine Fisheries Service, and the University of Southern Mississippi's Gulf Coast Research Lab.

From a series of seagrass trend studies both completed and in progress by NWRC for Perdido Bay, Chandeleur Islands, Gulf Islands National Seashore, and St. Andrews Bay, it was documented that the seagrass acreage in the bays and estuaries of the northern Gulf of Mexico is declining between 12% and 66%. Besides the acres of seagrasses being lost within the bays and estuaries over time, the seagrasses are also changing in species composition, densities, and patchiness. The causes of loss and changes of these valuable and productive habitats are many and complex and at the present time are not totally understood. Moreover, the signs or indicators of stress with the seagrass meadows, beds, and patches are not consistently and regionally monitored to provide a greater understanding of the seagrass loss and changes over time. The trend analysis of seagrass change in the northeastern Gulf of Mexico has helped to identify and document a very valuable ecosystem. This is aiding in the establishment of a comprehensive monitoring and assessment program, specifically focused on seagrasses, for the Gulf of Mexico Coast.

Use of AVIRIS Hyperspectral Imaging for Detection and Mapping of Leafy Spurge at Theodore Roosevelt National Park

Ralph Root, USGS, Center for Biological Informatics; Steve Hager and Bonnie Foster, National Park Service; Susan Ustin, Michael O'Neill, and George Scheer, University of California Davis, Center for Spatial Technologies and Remote Sensing; Rob Green, National Aeronautics and Space Administration, Jet Propulsion Laboratory; and Gerald Anderson, USDA, Agricultural Research Service

In July of 1999, AVIRIS data were obtained from the South Unit of Theodore Roosevelt National Park, North Dakota, which contains extensive stands of invasive leafy spurge. Ground spectra of leafy spurge and associated vegetation types were collected during the summers of 1998 and 1999. A geographic information systems (GIS) database was constructed showing locations of approximately 80 ground reference polygons, calibration sites, topography, roads, and streams, all registered to recently obtained digital orthophoto quarter quads. After georeferencing the AVIRIS data to the database, ground spectra will be related to the AVIRIS data and the image and ground spectra compared as a first step in developing training areas for mapping the leafy spurge by matching of spectral characteristics. If consistent and accurate (>80%) mapping of leafy spurge stands can be demonstrated, park managers will be able to more accurately locate and control this invasive plant. During the next 3 years we hope to extend these techniques to orbital hyperspectral sensors and track the plant in a more regional context.

Topics on Metadata

Building a Transboundary National Spatial Data Infrastructure/National Biological Information Infrastructure Metadata Clearinghouse Node for the Texas-Mexico Borderlands

Charles Palmer, Texas Water Development Board, TNRIS

Funded by a grant from the U.S. Geological Survey's Biological Resources Division, the Texas/Mexico Borderlands Information Center (BIC) has built an easily accessible clearinghouse node on the Internet that is compliant with National Spatial Data Infrastructure (NSDI) and National Biological Information Infrastructure (NBII) metadata standards for listing and describing multiuse environmental data files for the Texas-Mexico border region. The node has been designed so that the database is accessible through the BIC Web site or via the Federal Geographic Data Committee NBII clearinghouses. The node will be linked to other databases as well. The project provides metadata for datasets covering both sides of the border, with emphasis on the most frequently used maps and other geospatial data products. As of this writing, metadata for 40 datasets have been placed on the node. This presentation outlined the steps in building the node and provided useful advice for those who might be interested in doing the same.

(The author was provided with the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Metadata – The Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata Part 1: Biological Data Profile

Susan Stitt, Presented by Maury Nyquist, USGS, Center for Biological Informatics

The "Content Standard for Digital Geospatial Metadata, Part 1: Biological Data Profile" was officially approved as a Federal Geographic Data Committee (FGDC) standard in October 1999. This standard differs from the National Biological Information Infrastructure (NBII) metadata standard in several ways. There are new elements included, revised elements and structures, and changes in optionality. These differences include:

(1) Officially redefining the element "Spatial Domain" as mandatory if applicable to allow for documenting nongeospatial information in a consistent format. (*This change is officially new within the Biological Data Profile but was unofficially performed previously within the NBII metadata standard.)*

(2) Defining "Geospatial Data Presentation Form" as mandatory and extending its domain to include nongeospatial product types. This forces the documentation of the type of information being described and allows for distinct searches on geospatial and/or nongeospatial products (*new within the Biological Data Profile*).

(3) Adding information describing the taxa in the dataset (*reorganized from the NBII metadata standard, but elements remain the same*).
- Keywords
- Taxonomic system
- Taxonomic coverage
- Taxonomic classification system

(4) Adding elements to describe "Analytical Tools" and "Methodology" (*same as the NBII metadata standard*).
- Tools, models, or statistical procedures to which the data set is intrinsically bound (e.g., phylogenies, community ordinations, atmospheric/hydrological transport analyses).
- Information about a single step of field or laboratory work.

(5) Adding "Description of Geographic Extent." This consists of a short text description of the geographic extent of the data set. Examples include descriptions such as "Manistee River watershed," "ponds and reservoirs larger than 2 acres in Fall County, Michigan," or "In the Pacific Ocean, within 5 miles of the shore of the state of Washington" *(same as the NBII metadata standard).*

(6) Adding "Bounding Altitudes," which adds the ability to locate the vertical extent of a data set in association with its horizontal extent *(new to the Biological Data Profile*).

(7) Adding "ASCII File Structure," which provides the capability to completely and accurately describe the content and format of an ASCII data file. This structure was created with the goal of automated machine processing of this information for file transfer, data loading, and quality assurance *(new within the Biological Data Profile*).

(8) Adding "Geologic Age" elements which provide the capability to describe the geologic data relevant to a data set. This is provided as an optional alternative to the standard calendar dates *(new within the Biological Data Profile*).

(9) Expanding the domains of eight elements *(some of these are new within the Biological Data Profile, and some are the same as within the NBII metadata standard*):
- Currentness Reference
- Browse Graphic Format

- Logical Consistency Report
- Type of Source Media
- Source Currentness Reference
- Format Name
- Metadata Standard Name
- Geospatial Data Presentation Form

The standard can be downloaded at http://www.fgdc.gov/standards/status/sub5_2.html.

Metadata: Your Key to Documenting and Discovering Data

Jennifer A. Gaines, USGS, Office of Biological Informatics

Executive Order 12906 mandated all federal agencies to create and share information about their data sets using the federal metadata standard. The order also gave the Federal Geographic Data Committee (FGDC) the responsibility of creating a Web-based searchable clearinghouse beginning in 1995. However, no guidelines were established for implementing the metadata concept. This presentation reviewed current U.S. Geological Survey (USGS) policies and implementation procedures for the USGS Biological Resources Division (USGS-BRD). U.S. Geological Survey policies include memorandums from the Director's office as well as internal policies within the major disciplines that outline metadata responsibilities of managers and researchers at all levels of the organization. The USGS-BRD metadata policy #8, signed in 1998, provides guidelines for documenting all biological data sets in compliance with FGDC and the Biological Data Profile metadata standard, requires metadata records to be accessible through the NBII Clearinghouse Gateway, and suggests using MetaMaker as the metadata collection tool. The USGS-BRD, in conjunction with the National Biological Information Infrastructure (NBII) Program and FGDC, have assisted personnel within USGS as well as partner organizations to meet their responsibilities for creating and serving metadata by conducting training, providing software, and developing clearinghouse nodes. More than 50 training workshops have been conducted across the country for more than 400 individuals representing organizations from federal, state, local, and tribal governments, nonprofit groups, museums, universities, and private industry. Participants in the workshops get hands-on experience creating metadata for their own data sets by using the NBII developed MetaMaker software. The initial NBII metadata training instructors group has been expanded to include trainers from all over the country from the USGS, the National Park Service, and the Conservation Management Institute's Fish and Wildlife Information Exchange in Virginia. In addition to training, workshop participants are encouraged to develop clearinghouse nodes within the network to increase discovery of data sets for their organization, region, or discipline. Since 1995, the NBII Clearinghouse Gateway has been extended to include nodes from many organizations including:

- National Biological Information Infrastructure Metadata Clearinghouse
- Columbia Environmental Research Center's Metadata Node
- Eastern Sierra Geospatial Data Clearinghouse
- EMAN Data Set Library (Environment Canada Server)
- Forest, Aquatic, and Rangeland Ecosystems in the Western USA
- National Wetlands Research Center (NWRC) Spatial Data and Metadata Server Node
- New Mexico Resource Geographic Information System Clearinghouse
- New Mexico USGS Partnership Clearinghouse
- Southwest Region Road Map of Natural Resource Data and Information Clearinghouse for the Olympic Peninsula
- A Transboundary NSDI/NBII Metadata Clearinghouse node for the Texas/Mexico Borderlands
- Texas Natural Resources Information Systems (TNRIS)
- Washington State Geospatial Clearinghouse - All Nodes
- Wyoming Natural Resources Data Clearinghouse

Metadata SWAT Teams: A Success Story in Creating a Regional Clearinghouse Node

Robert A. Norheim, USGS, Forest and Rangeland Ecosystem Science Center

We are developing a comprehensive database of metadata for biological and geospatial information for the Olympic Peninsula in Washington state. Several factors make the Olympic Peninsula ripe for the kind of partnerships envisioned by the National Spatial Data Infrastructure. On the peninsula, land ownership, topography, and climate are all diverse, making for a variety of both ecological communities and management objectives. Also, there were significant political and social conflicts on the peninsula during the Pacific Northwest timber crisis of the late 1980's and early 1990's. The conflicts arose because of disagreements about the use of natural resources on public lands. The metadata collection is being delivered to the Olympic Natural Resources Center (ONRC), which serves as an "honest broker" for the diverse interests of the peninsula community. The Olympic metadata clearinghouse node has become a single, easy-access point through which land managers, scientists, decision-makers and citizens of the Olympic

Peninsula can preview and acquire information on natural resources.

However, our experience is that collecting metadata is not as simple as putting up a Web site and waiting for metadata to come pouring in. Despite executive orders and agency mandates, and despite most geographic information system (GIS) analysts knowing that metadata is the right thing to do, it is still a low priority (and largely unfunded) activity. To overcome this lack of interest, we have developed a successful approach to encouraging a wide variety of partners to develop metadata. Rather than relying on contributors developing their own metadata (often seen as an impossible task because of the need to document large legacy datasets), we send in a team of metadata specialists. This team can quickly document a set of coverages, both providing a service to the contributor (who now has their legacy data documented) and also adding to the collection of metadata and data available for the peninsula community.

The team expanded its work beyond larger holders of geospatial data to the diversity of data holders on the peninsula, many of whom had not heard of metadata before. We initiated contact with them, educated them about our project, and then educated them about metadata. The metadata team also educates partners about metadata software, the need for metadata, and the flexibility of the federal metadata standard to handle special situations such as proprietary data. In some cases the team converted metadata in proprietary formats to Federal Geographic Data Committee-compliant metadata. The team has produced tremendous good will for the clearinghouse node, which now has a large collection of metadata from a broad diversity of partners, and is considered a regional resource. In addition, ONRC considers the clearinghouse to be one of its most successful programs, and the clearinghouse has generated positive exposure for ONRC in the wider community.

For more information: http://ww.onrc.washington.edu/ and http://www.cfr.washington.edu/research.usgs/cascadia/.

Topics on Vegetation Sampling and Mapping

A Geospatial Solution to Problems with Siting Wetland Vegetation Sampling Transects Near a Sinuous Creek in Seney National Wildlife Refuge, Michigan

Kurt P. Kowalski, USGS, Great Lakes Science Center

Research related to a wetland restoration project at Seney National Wildlife Refuge, Michigan, required sampling sedge-fen plant communities along transects parallel to the flow of water in a small, sinuous creek. Sampling along straight transects at specified distances from the water's edge, as dictated in the study plan, was not possible because of the curves in the creek. Decision rules were therefore created to guide the placement of sampling locations and standardize the sampling procedures. A Differential Global Positioning System (DGPS) receiver and geographic information system (GIS) software were then used to select sampling locations that met the distance-to-water's edge criteria.

Since no other geospatial data (e.g., digital orthophotos) were available, a Trimble ProXR DGPS was used to delineate the shorelines of the creek as line features. Differential correction of the GPS data was required to accurately delineate the sinuosity of the creek. The data were exported to ESRI's ArcView GIS software (Redlands, California) where buffers were created at the desired distances from the creek. The size of the buffers was correlated to the required distance from the water's edge for each transect. This process created a framework to guide the placement of the transects and plant sampling quadrats. The software was used to identify the geographic location of sampling points so they met the criteria defined in the decision rules.

The coordinates of the sampling locations were recorded from the GIS software and entered into the DGPS receiver as waypoints. The DGPS receiver was then used to navigate to each of the waypoints (i.e., sample locations) where a flag was placed in the ground. After all of the sample sites were identified and marked, the actual plant sampling commenced. Application of geospatial technologies thus allowed the efficient placement of sampling transects that would have otherwise been extremely difficult and time-consuming to construct by using manual measurement techniques.

Remote Sensing and Geographic Information Support for Water Hyacinth Management on Lake Victoria, East Africa[1]

Thomas P. Albright, Raytheon Information Technology and Scientific Services, EROS Data Center; and Larry L. Tieszen, USGS, EROS Data Center

The invasive plant water hyacinth (*Eichhornia crassipes*) was first documented on Lake Victoria, East Africa, in the late 1980's. Some negative effects attributed to the arrival of this species include modification of aquatic and wetland environments; impediment to shore access, drinking water collection, and production of hydroelectric power; and provision of habitat for disease bearing organisms. In response to this situation, a control and management program is being implemented by national, regional, and international entities. As a component of this effort, the U.S. Geological Survey's

Earth Resources Observation Systems (EROS) Data Center is developing a program with its partner Clean Lakes, Inc., to build the capacity of East African nations to use remote sensing and geographic information systems (GIS) to monitor Lake Victoria and its basin.

Information on weed distribution and coverage is important to assess the trends in water hyacinth, confirm reports from field officers, assess the efficacy of control measures, and provide early warning so that measures can be taken before the problem reaches a critical state. We are using a combination of optical and radar satellite imagery, aerial photography, and field visits to estimate coverage and distribution of water hyacinth on the lake. We recently conducted a pilot study on Winam Gulf, Kenya, using Radarsat, which demonstrated the feasibility of mapping water hyacinth distribution and estimating coverage using this sensor. While it cannot penetrate cloud cover as radar instruments can, Landsat 7 is also well suited to mapping this phenomenon and is being used by the project when cloud free images are available. Corroboration and finer scale information can be obtained through aerial photography and field visits. Another component of the project involves the integration, processing, and analysis of information pertaining to biophysical characteristics of the tributary that flows from the basin to the lake. This type of information may provide insight into the relationships among land cover, soils, slopes, water quality, and water hyacinth distribution. Finally, in order to make information from this and other projects more accessible and useful, an information system is being developed, which will include an Internet-based geographic data clearinghouse. We will develop and support the capacity of East African institutions to carry out each of these aspects of the project.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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[1]Work performed under U.S. Geological Survey contract 1434-CR-97-CN-40274.

A New National Mosaic of State Landcover Data

Ian Thomas, APL Inc., Patuxent Wildlife Research Center

This presentation reviewed current landcover mapping efforts and presented a new preliminary, national mosaic of Gap Analysis Program (GAP) and Multi-Resolution Land Characteristics Consortium (MRLC) landcover data with a discussion of techniques, problems faced, and future refinements.

(The author was provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Panel Sessions

Remote Sensing

From an Ominous Beginning to an Auspicious Future: Satellite Remote Sensing in the 21st Century

Tom Loveland, USGS, EROS Data Center

The acceptance and utility of remotely sensed data has blossomed since the early days of civil land remote sensing. We have gone through a 30-year period of technical advances, policy changes, and uncertain levels of operational commitment and are now realizing the long-expected benefits of routine Earth observations. Landsat data have become routine inputs for environmental assessments, and data from the Shuttle Program, meteorological satellites, microwave missions, and other satellite programs have become practical tools for scientists, environmental specialists, resource managers, and planners. As we cross into the 21st century, we will have access to even more innovative forms of multisource and multiscale remotely sensed data. Satellites with instruments that collect very high spatial resolution images, and hyperspectral, microwave, and Lidar data sets will become available in the next year. In addition, there is a clear trend toward the routine development of operational land products that provide quantitative measures of the biophysical and phenological properties of the landscape. These technological and data advances are finding an important niche in the new generations of spatial earth systems models that are rapidly being incorporated into the daily business of environmental scientists.

Possibilities and Pitfalls in the Use of Remote Sensed Data for Mapping and Characterizing a Dynamic Landscape

Tom Loveland, USGS, EROS Data Center

Remotely sensed data, ranging from historical aerial photography to contemporary satellite imagery, are invaluable for mapping and measuring the patterns, characteristics, and dynamics of vegetation and land cover. Successful use of remotely sensed data is dependent upon the effective matching of the problem being investigated and the characteristics of the landscape with the technical specifications of remotely sensed data. The range of available instruments, formats, scales, and temporal dimensions that can be used in landscape characterization is overwhelming. Our experience in mapping land cover and vegetation from local to national to global scales provides valuable lessons regarding the

critical need to match information requirements with the technical characteristics of remotely sensed data. While larger scale sources with rich spectral content generally yield more detailed vegetation descriptions, coarse scale sources with high temporal frequency can provide quite specific landscape attributes. The basic issue that must be faced, however, is the sometimes ambiguous relationship between remotely sensed data and the required landscape information. To be successful, careful planning must be the central element in any landscape mapping and characterization project.

Status of the Commercial One-Meter Satellite Data

Bruce Davis, NASA, John C. Stennis Space Center

Within the next 12 months, three major aerospace companies are expecting to launch panchromatic and multispectral orbital sensors with approximately 1-meter and 4- to 5-meter spatial resolution, respectively. Such sensors are likely to revolutionize the imaging world, making high-resolution repetitive coverage available to planners, researchers, and land managers. Briefings will be presented on each of these three companies' systems, including capabilities, status if already launched, expected launch dates, and anticipated pricing of imagery.

The Commercial Remote Sensing Program (CRSP) at NASA's Stennis Space Center was formed to help commercialize remote sensing, geographic information systems, and related imaging technologies. Through various partnership programs, the CRSP has helped share NASA's technology and expertise with hundreds of private companies, agencies, and educational centers.

The author was provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.

Radar Data for Vegetation Mapping

K. Jon Ranson, NASA, Goddard Space Flight Center

Synthetic aperture radars have unique capabilities for monitoring and mapping vegetation. Radars can be used at night or over cloud-covered areas. In addition, the radar signals can penetrate vegetation canopies and provide information about canopy structure and the underlying ground surface. Radars have been found to be able to discriminate vegetation communities with different species, ages, spatial structure, and surface conditions. This level of discrimination is possible because plants with particular orientations of branches, stems, and foliage produce different radar returns as a function of radar wavelength, polarization, and incidence angle. Because of limited penetration length through the canopy, shorter wavelength C-band (6 cm) radars mainly see the top of dense forests but will sense ground surfaces when there is a gap. Longer wavelength radars, for example L-band (23 cm), capable of greater signal penetration, will sense the woody structure and underlying surfaces of forests. Because of the sensitivity to forest structure lower in the canopy, radar data can reveal information about vegetation that is complementary to optical satellite data.

Currently radar systems used for vegetation analysis include airborne and space-borne systems. This presentation concentrated on data and capabilities of available satellite-borne radars. These systems include the European Earth Resources Satellite (ERS) 1 and 2, the Canadian Radarsat, and the Japanese Earth Resources Satellite (JERS) -1. Although archival data is still available for ERS-1 and JERS-1, both systems are no longer in operation. Another radar system suitable for research purposes, the NASA Shuttle Imaging Radar – C (SIR-C) mission was discussed. SIR-C was flown in 1994 with three radars with multiple polarizations making these data suitable for understanding the vegetation mapping capabilities of existing and future space-borne radars. The SIR-C data is limited in geographic coverage but is inexpensive and easily accessible from the Earth Resources Observation Systems (EROS) Data Center. Future space-borne radars include the European Envisat ASAR (scheduled for launch in 2000), Radarsat 2 (2002), and the Japanese ALOS (2002). All of these systems promise enhanced features either with multiple polarizations or longer wavelengths and should contribute greatly to the increased understanding of global vegetation.

Hyperspectral Imaging

Elijah W. Ramsey III, USGS, National Wetlands Research Center

Typically, the remote sensing of vegetation reflectance has used broad spectral band sensors (e.g., Landsat Multispectral Scanner and Landsat Thematic Mapper) that are adequate only for slowly varying regions of the spectra with respect to wavelength. These broadband measurements may retrieve information on dominant canopy reflectance features such as chlorophyll absorption in the visible wavelengths, cellular structure in the near infrared wavelengths, and water absorption in the shortwave wavelengths, but specific spectral features associated with fine structure in spectra are irretrievable. This lack of detailed diagnostic wavelength information has led to research combining laboratory leaf spectroscopy with high-resolution aircraft and satellite remote sensing technologies.

The development of airborne imaging spectrometers has enabled the creation of contiguous reflectance spectra (generally over 200 bands)—with spectral resolution comparable to laboratory spectrometers—for each pixel within a remotely sensed image. Spatial variances in hyperspectral imagery have been related to changes in canopy vegetation type, lignin concentration, and foliar water content. In a study of wetland cover delineation, however, it was not possible to separate influences of sensor noise, canopy geometry, or leaf biochemical properties on the absorption features within the recorded aircraft hyperspectral spectra. To explain reflectance characteristics of an entire canopy, it is generally insufficient to rely only on the leaf reflectance spectra when the canopy reflectance includes many additional complexities. The development of hyperspectral remote sensing techniques for wetland mapping (forest and marsh) has been limited by (1) the dearth of simultaneously collected site-specific data describing canopy structure (e.g., leaf area index, species composition) and remote sensing data; (2) the use of simplistic relationships that did not account for plant or canopy characteristics or changes in the sun and view angles; (3) the lack of procedures to relate information content to the spectral resolution; and (4) the failure to sustain an analysis of ground-based or remotely sensed data.

The adaptation of new optical tools and the development of new techniques for measuring and defining the canopy structure, leaf optical properties, and canopy background has now allowed the collection of necessary canopy information for calibration of the hyperspectral image data and validation of light-canopy interaction models. Canopy models are providing the link between the canopy characteristics (community type, structure, leaf optical properties, background) and the hyperspectral image data. By using hyperspectral measurements of reflected radiation from the canopy, an accurate canopy model can provide not only canopy structural and leaf optical information but also can be used to examine the spatial variability in different wetland ecosystems.

In wetland environments, canopy type, biomass composition, and health can vary with canopy structure and leaf spectral properties. Thus, once the biophysical properties are linked to the hyperspectral data, the changes in wetland type, biomass composition, and health can be mapped without reliance on changing inferential relationships. This will accelerate the development of a regional as well as a global comprehensive database that includes both the physical extent of wetlands and wetland community distribution. This, in turn, will lead to a sustainable management of the world's wetlands in the face of mounting and detrimental human-induced and natural forces.

Gap Analysis Program Applications

The Gap Analysis Program: An Update on Status, Implementation, and Decision Support Systems

Patrick J. Crist, USGS, Gap Analysis Program

The Gap Analysis Program (GAP) is in its tenth year of operation, and for a majority of the conterminous 48 states, gap analysis will be completed by the end of calendar year 2000. Data products, which include the final report and graphics of hundreds of maps as well as the geographic information system (GIS) data, are provided on CD-ROM and the Internet. The data has thus far been put to hundreds of uses, but because it is novel to traditional decision-making processes, a concerted effort is required to ensure its broad and proper application to conservation planning. We have found that even institutions sophisticated in GIS have had difficulty incorporating GAP data because it is both detailed in resolution and covers large geographic areas, and especially in the case of animal distributions, it is probabilistic. We hypothesized that desktop decision support systems (DSS) could aid likely customers in the use of the information, and we obtained Biological Resources Division State Partnership Grant funding to develop two pilot DSS systems. The first system was developed for county land-use planners in Teton and Sublette Counties, Wyoming, and is called the Biodiversity Expert Systems Tool (BEST). The BEST is geared to the development application phase and aids planners in identifying potential conflicts and mitigation measures between proposed land uses and elements of biodiversity mapped by GAP as well as other more local information. The second system was developed for the U.S. Fish and Wildlife Service and is called Refuge-GAP. It provides a sophisticated interface that allows biologists to explore the biological context of National Wildlife Refuges or of any other user-defined location and to build queries to identify places of high coincidence of elements of interest. An additional "canned" interface demonstrates the ability to incorporate the agency's Land Acquisition Prioritization System (LAPS) into a desktop DSS to facilitate identification of new lands to add to existing refuges or locations for new refuges based on LAPS criteria combined with GAP and other publicly available data. We concluded from these pilot projects that DSS are fairly simple and inexpensive to develop and are likely valuable tools for implementing GAP. The systems and data are available to aid managers in making better decisions today, but considerable scientific needs still exist to create more robust systems with higher confidence results. These needs include far

greater integration of biological databases nationwide and required standardized capture of field inventory information.

A Gap Approach to Modeling Biodiversity

Kimberly G. Smith, Donald Catanzaro, Thomas Brooks, James Taulman, and W. Fredrick Limp, University of Arkansas

Gap analysis is an approach for mapping the predicted distributions of animals on the landscape for conservation planning. In the basic approach, a current vegetation map is used to predict the distribution of animals by assuming that animals occur in all suitable habitats within their known range. Predicted distributions of all terrestrial vertebrates are then overlaid on a map of ownership to determine areas of high biodiversity that are outside of current managed areas. Also, species for which insufficient areas of suitable habitat have been protected become apparent. We used this approach to predict the distributions of breeding birds within the state of Arkansas. Using the U.S. Environmental Protection Agency's 365 km^2 hexagons as sampling units, we identified the five regions with the highest conservation concern in the state based on bird distributions. In a truncated gap analysis, the vegetation data layer is unavailable (or nonexistent), but distributions of animals and boundaries of managed areas are known. We demonstrate the usefulness of that approach by examining permanent resident birds at risk in Latin America in general and in Paraguay and Columbia in particular. Using complementary "hot spots" (i.e., areas that complement each other in the suite of species protected), as few as six spots within Paraguay can be chosen to potentially protect the 38 species of birds at risk, and only 38 areas are needed in Columbia to potentially protect the 379 species at risk in that country. Gap models are, in effect, testable hypotheses concerning the patterns of biodiversity on the landscape which allow managers to make effective data-based decisions.

Enhancing Natural Resource Management and Biodiversity Protection with Gap Analysis Data

Richard B. Minnis and Francisco J. Vilella, Mississippi State University, Mississippi Cooperative Fish and Wildlife Research Unit

The Mississippi Gap Analysis Program (MS-GAP) is a rapid, large-scale assessment of the habitat distribution and protective status of all Mississippi's terrestrial vertebrate species. Data developed by MS-GAP are applicable to a diversity of natural resource issues beyond the application of reserve design. MS-GAP data have been or are being used for determining priority lands by Partners-in-Flight, examining swallow-tailed kite nesting habitat, evaluating maximum daily pollution loads, and land planning by local governments. Although data developed from MS-GAP are being widely used, one product developed by MS-GAP has been more requested than any other: knowledge, or the ability to use and develop spatial data for addressing natural resource issues. The knowledge generated from developing MS-GAP has allowed us to aid federal, state, and nongovernment organizations to more effectively plan and implement natural resource management. Many organizations realize the need and uses for spatial data in natural resources management; however, they often lack the geographic information system (GIS) skills to do so. MS-GAP has played a vital role in providing this knowledge.

Natural resource managers are slowly learning how spatial technologies and spatial data can be used to solve many resource problems. The factor preventing most managers, who are predominantly biologists, from greater use of these technologies is knowledge; they often lack training in the use of GIS and remote sensing. These resource managers require an interface for this technology, either through simplistic computer applications such as the animal movements module developed by the U.S. Geological Survey, or direct contact with a person knowledgeable in both biology and spatial technology. To address this issue in Mississippi, the Department of Wildlife and Fisheries in the Forest and Wildlife Research Center at Mississippi State University has put before the State legislature an initiative to develop the Natural Resources Decision Support System (NRDSS). The NRDSS would provide natural resource managers and policy makers the support they need to apply existing spatial data to solve problems and implement policy involving natural resource management. The support from the NRDSS would be in the form of available staff members, customized applications, and simple computer interfaces to existing spatial data and models.

Plenary Sessions

Telemetry

Telemetry Applications at the U.S. Geological Survey's Alaska Biological Science Center

David C. Douglas, USGS, Alaska Biological Science Center

Telemetry continues to be a fundamental tool for wildlife research and management. Numerous technological developments over the past 2 decades have greatly expanded the capabilities of wildlife telemetry. At the U.S. Geological Survey's Alaska Biological Science Center, telemetry has been essential for studying animal populations with extensive migratory behaviors across remote expanses of the arctic landscape. While conventional radio telemetry continues to be a primary technique, several studies have been initiated or augmented with satellite tracking technologies. Satellites have been instrumental in learning about the distributions and migrations of polar bear, caribou, and walrus, as well as several avian species including eiders, swans, ducks, and geese. Other studies have used sonic telemetry to investigate the dive behavior of sea otters and biotelemetry to study heart rates of geese under various disturbance regimes. Global positioning system (GPS) receivers have been attached to caribou and wolves to ascertain detailed accounts about distribution and habitat use. Contact the Alaska Biological Science Center to learn more about specific research projects, or visit http://www.absc.usgs.gov.

Telemetry in the Aquatic Environment: Where We Are and Where We're Headed

John W. Beeman and Noah Adams, USGS, Western Fisheries Research Center

Advances in technology and miniaturization make this an exciting time in the field of aquatic biotelemetry. In many cases, these advances can be used to either improve existing tools or create new ones to answer biological questions. Examples include smaller sensors to determine depth and temperature and more advanced systems to collect telemetry data such as flexible, Windows-based systems able to simultaneously monitor 50 inputs (i.e., antennas) and acoustic systems capable of determining three-dimensional positions of juvenile salmon with submeter accuracy.

Researchers at the Western Fisheries Research Center's Columbia River Research Laboratory have been using telemetry to collect information from freshwater fish since the mid-1980's. Many innovative tools and approaches have been used to meet the information needs of client agencies. These tools and approaches range from relatively simple systems based on mobile-tracking of several dozen fish to elaborate radio systems with hundreds of antennas to monitor thousands of fish. In a study to assess the relative risk of resident fish to total dissolved gas supersaturation, a program to determine the prevalence and severity of gas bubble disease (GBD) was coupled with acoustic telemetry to determine the vertical and horizontal locations of selected species. In addition, depths of commercial fish reared in a net pen were assessed by using data archive tags. The results will be used to determine the extent of GBD in resident fish and the amount of hydrostatic compensation available in resident and commercially reared fish in the reservoir. The U.S. Bureau of Reclamation will use these data as an aid in designing and implementing multimillion dollar gas abatement structures at Grand Coulee Dam, Columbia River, Washington. In a more complex study design, the approach and passage patterns of over 4,000 juvenile salmonids were determined over a 3-year period in front of Lower Granite Dam, Snake River, Washington. This study was based on arrays of over 280 aerial and underwater antennas, allowing almost continuous location information as fish approached and passed the dam. Locating the fish was possible by advanced coding schemes, underwater dipole antennas, equipment to instantaneously monitor multiple antennas, and balancing receiver inputs using signal amplifiers and attenuators. The results of this study are being used by the U.S. Army Corps of Engineers to modify prototype fish collection systems at federal hydroelectric dams on the Columbia and Snake Rivers.

The future of aquatic biotelemetry will be driven by the integration of biological needs with advances in technology. Scientists and their clients need information from smaller fish, on finer measurement scales, and with smaller budgets. New telemetry tools are a product of advances in technologies and are made possible only if scientists communicate their needs to the industry. Miniature sensors, three-dimensional tracking systems, combined radio and acoustic transmitters, and flexible, user-friendly receiving systems are examples of new tools entering the market. These innovations were born from the interactions between biologists and industry. The role of the Biological Resources Division in aquatic biotelemetry is, and should continue to be, as a leader in technological advancement to meet the research and management needs of our Nation's biological resources.

National Vegetation Classification System

The National Vegetation Classification System: Background and Current Status

Denny Grossman, The Nature Conservancy

Over the past 20 years, The Nature Conservancy has worked to consider ecological communities, in addition to targeted species, in conservation planning; however, the absence of a standardized approach to community classification across the United States and North America has hampered the implementation of this ecological approach to conservation. In response to this lack of standardized information, The Nature Conservancy committed to work with the network of state Natural Heritage Programs and International Conservation Data Centers to develop and populate a standardized classification system. Over many years and in collaboration with numerous academic and agency partners, a team of ecologists developed a structure and associated rules for a standardized, hierarchical, physiognomic/floristic vegetation classification for terrestrial and emergent aquatic communities. This classification structure has largely been populated through the analysis and integration of existing state Natural Heritage vegetation units. Gaps and weaknesses in the classification have been documented, and many of these gaps are being addressed through the collection and analysis of new data. At present, approximately 1,700 vegetation alliances and 5,700 vegetation associations have been defined at the floristic levels of the classification hierarchy. Numerous federal programs have now adopted this classification standard, most notably the National Park Service's Vegetation Mapping Program and the U.S. Geological Survey, Biological Resources Division's Gap Analysis Program. In 1997 the Federal Geographic Data Committee endorsed this system as the standard for vegetation information and classification to be used by all federal agencies. The Ecological Society of America has become involved through the establishment of a vegetation classification panel to help develop and document standards for the floristic levels of the hierarchy. Recent activities have focused on the development of standardized databases for the integrated management and delivery of classification information. The Association for Biodiversity Information expects to serve the classification units with descriptive and conservation information on a public Web site in the fall of 2000.

National Vegetation Classification Standard and the U.S. Geological Survey-National Park Service Vegetation Mapping Program: A Case Study at Voyageurs National Park

Samuel Lammie, Voyageurs National Park

Voyageurs National Park, Minnesota, is nearing completion on a 3-year vegetation mapping project. The project, a partnership between the U.S. Geological Survey and the National Park Service, used The Nature Conservancy's U.S. National Vegetation Classification (USNVC) to develop a uniform, hierarchical vegetation classification for 54,243 ha of terrestrial habitat, ranging from transitional southern boreal forest to diverse wetlands. Photointerpretation of 1995 and 1996 1:15,840 color infrared aerial photographs (CIR) were used to develop vegetation types at a mapped scale of 1:24,000. Verification trips followed preliminary mapping to ensure that classification and mapping protocols were coordinated. Field surveys identified 51 natural associations, plus cultural and land-use/landcover units. A preliminary or beta vegetation map is now being used as a tool to locate forest bird breeding survey plots and to identify rare types and species. The final vegetation map will facilitate development of a vegetation management plan. This plan will enable the park to better meet the congressional mandate of preserving, "...for the inspiration and enjoyment of present and future generations, the outstanding scenery, geological conditions, and waterway system which constituted a part of that historic route of the Voyageurs who contributed significantly to the opening of the Northwestern United States."

(The author was provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Implementing the National Vegetation Classification Standard in Mapping and Classification Vegetation Projects

Thomas Owens, USGS, Center for Biological Informatics

On October 22, 1997, Secretary of the Interior Bruce Babbitt, as the Chair of the Federal Geographic Data Committee (FGDC), endorsed the Committee's approval of the National Vegetation Classification and Information Standards. This system will now be the standard vegetation classification for use by federal government agencies and their cooperators. The benefits to using the National Vegetation Classification System (NVCS) include (1) the NVCS is a peer-reviewed, scientifically sound vegetation community classification system;

(2) the NVCS is consistent with other classification projects; (3) the NVCS provides an appropriate level of resolution that is useful to natural resource management and scientific monitoring and inventory; and (4) the NVCS meets the FGDC standard. Two U.S. Geological Survey programs, the Gap Analysis Program (GAP) and the U.S. Geological Survey - National Park Service Vegetation Mapping Program (VMP), are currently using the NVCS in their work, and in fact, are extending it. The major issues that GAP and VMP have encountered in implementing the NVCS are (1) the level of development of the NVCS where many classes have not been defined or described, (2) the ability of remote sensing technology to discern lower levels in the classification, and (3) the lack of trained experts in developing the NVCS in different regions of the country. Considerations a principal investigator must take into account when considering classifying vegetation using the NVCS are (1) the cost of implementation, (2) finding experts who can perform the field work and data analysis, and (3) integrating with remote sensing and mapping technology.

Concurrent Workshop Sessions

Global Positioning System Workshop

Karl Brown, USGS, Center for Biological Informatics

The Global Positioning System (GPS) workshop integrated and compared the success of the crypto-enabled (PLGR+96) equipment in biological studies and applications with alternative nonkeyed GPS tools for real-time positioning needs. This comparison indicated that PLGR+96 accuracies were superior to uncorrected C/A code (civilian) receivers, particularly in tree canopy and north aspect environments. The workshop also discussed new developments in differential equipment, coverage, advanced PLGR+96 features, and functionality. Additionally, data fusion tools, techniques, applications, and developing real-time differential equipment were displayed.

Agenda

1(a) Review of PLGR and GPS as it relates to biological research (10 min)
- Background information on GPS
- Overview of GPS capabilities for biological research – Precise Positioning Service (PPS) versus Standard Positioning Service (SPS) (real-time versus post-processed differential)
- Pitfalls of any GPS use for field studies (e.g., datum selection, battery consumption, signal problems, etc.)
- Restrictions of GPS use and security considerations; petition process for nonfederal PLGR use; PLGR needed for out-of-country project travel.

1(b). Advanced PLGR capabilities for biological applications (40 min)
- Real-time navigation to study sites (differential and PPS)
- Two-post survey
- Using alerts
- Use with laser range finders and other instruments (sonar, depth finders, etc.)
- Serial output and NMEA setup
- Real-time differential use of PLGR
- Getting data from PLGR into geographic information systems (e.g., ArcView)
- Use with mission planning software; data upload to the PLGR

2. Applications of PLGR to biological research or operational needs (60 min)
- Example applications illustrating above topics, drawing on U.S. Geological Survey (USGS) Biological Resources Division and U.S. Fish and Wildlife Service projects around the country
- Laser rangefinder use (e.g., Greg Kennedy at USGS Great Lakes Science Center)
- MBX-3 Differential with PLGR+96 and other handhelds, (e.g., GeoExplorer)
- Garmin C/A code 3+ with GBR-21 beacon receiver and H-field antenna

In summary, the attendees reviewed the error factors in C/A code and crypto-enabled receivers and gained insight into data fusion tool options and the coming expansion of the U.S. Coast Guard real-time differential network of transmitting beacon base stations. Inexpensive C/A code receivers **may** provide sufficient accuracy when linked to a real-time differential beacon for navigation and positioning. Under tree canopy reception and areas of limited sky visibility continue to challenge scientists in their positioning needs, and the C/A code receivers do not perform as well as the crypto-enabled PLGR+96 under these low signal strength and limited sky view conditions.

Department of the Interior Narrowbanding Issues

Wayne Wiltz, USGS, National Wetlands Research Center

To keep up with the increasing demand for new frequency assignments, the National Telecommunications and Information Administration (NTIA) required that all federal government radio systems, Very High Frequency (VHF, 162-174 Mhz) and Ultra High Frequency (UHF, 406-420 Mhz), be converted to narrowband (12.5 kHz channel spacing) operation.

Transition to narrowband frequency assignments must be completed by January 1, 2005 for VHF systems and January 1, 2008 for UHF systems. The number of discrete channels available for assignment will basically double after the transition is completed and will reduce the chances of interference between VHF and UHF systems. Questions arise when the term "radio system" is used to describe equipment affected by the mandate. As a guide or "rule of thumb," any device which requires a frequency to operate is considered a radio system and will be subject to narrowbanding guidelines. In order to inform and assist the U.S. Geological Survey (USGS)/ Biological Resources Division (BRD) in incorporating the narrowbanding technology into their radio infrastructure, a Web-based manual was created providing them with the resources to do just that. This Web-based manual can be accessed at http://biology.usgs.gov/irm/radio. Requests involving telemetry and wireless projects/applications are the most common in BRD. A telemetry request requires a person to complete a form provided by the National Communications Center (NCC) so that information can be gathered about projects requiring frequency approval. Once the form is completed it is sent to the BRD Radio Officer who then reviews it and forwards it to the NCC. The NCC also reviews the form and provides the requestor with an approved frequency range to operate their equipment in an area without any interference. To complete a wireless radio frequency authorization (RFA), three items are needed: (1) RFA ASCII format of information pertaining to the system design, (2) a map of the geographic location where the system will be located, and (3) a system design drawing. The requestor is required by the Department of the Interior to use the following software packages for the preparation of the RFA information: MicroPath 2000 for system design, site maps, and coverage charts; Map Expert for verification job site latitude and longitude; DesignCAD 2-D Version 7.0 for the completion of a system design drawing; and NTIAFREQ, frequency management software that produces an ASCII format for the RFA card formats. The time frame for frequency approval for a telemetry request is about 1 week and for a wireless request ranges between 6 months to 1 year.

Animal Movement and ArcView Tool Creation

Philip N. Hooge, USGS, Alaska Biological Science Center

Animal Movement Workshop

This workshop concentrated on the tools available for the analysis of animal movements with special emphasis on performing such analysis in a geographic information systems (GIS) environment. The content of this workshop was geared toward a wide audience with open exchange and questions encouraged. We reviewed the available software, covering their capabilities and limitations before spending the majority of the workshop on the use of ArcView GIS and the animal movement extension. A step-wise approach was emphasized for testing the assumptions and patterns of the data before using many of the models. We discussed various methods of home range analysis, tests for complete spatial randomness, circular statistics, Monte Carlo simulations, habitat selection models, interaction statistics, exploratory analysis, and manipulation of spatial data sets. Examples were drawn from tracking projects on both terrestrial and aquatic species.

ArcView Tool Creation Workshop

This workshop also concentrated on the process of creating tools using ArcView. The pros and cons of using the Avenue programming language and using the extension capability of ArcView were discussed. This workshop was geared toward those who desire to produce biological GIS tools that can be widely distributed with the minimum development time. Examples were drawn from several extensions created at the Alaska Biological Science Center including the animal movement extension, the spatial tools extension (integrating Spatial Analyst), the population viability analysis extension, the CTD analyst extension (integrating 3D Analyst), and the event logger extension (integrating Tracking Analyst). It was not necessary to have experience with Avenue, but a basic knowledge of ArcView as well as some experience in basic programming was assumed. The workshop was useful to individuals who may be contracting for the creation of tools as well as to those considering using Visual Basic instead of Avenue with the release of Version 4.0 of ArcView. The discussion was steered toward the needs of the group attending; open dialog and questions were encouraged.

(The author was provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Satellite Telemetry Workshop

David C. Douglas, USGS, Alaska Biological Science Center

Drawing upon the Alaska Biological Science Center's 15 years of experience, this workshop presented a breadth of technical information about using the Argos Data Collection and Location System for tracking wildlife from satellite. The workshop focused on two fundamental aspects of satellite telemetry: (1) study design and (2) data analysis. The study design section considered

strategies for maximizing information return and included topics such as transmitter technologies, satellite coverage, transmitter duty cycles, ancillary sensor data, and general costs. The analysis section considered how to manage and interpret the large volumes of data that are typically attained through satellite retrieval and included topics such as software tools and methods for assessing the accuracy of the recovered locations.

Initial financial costs for conducting a satellite telemetry study are relatively large, but in many cases, it is more cost-effective than traditional methods. This is especially true for animals expected to move large distances, perhaps across international borders or into very remote or inhospitable territories where conventional radio tracking becomes expensive, if not impossible. Satellite transmitters (often called PTT's) are produced by several manufacturers that are documented under the Service Argos homepages, along with all other necessary information for utilizing the French-based satellite tracking system (http://www.cls.fr/html/argos/welcome_en.html or http://www.argosinc.com). Satellite transmitters vary widely in size, from as little as 20 g for avian applications to several kilograms for elephants. Cost for a single PTT typically ranges between $2,000 - $3,000, and additional Service Argos data processing costs are roughly about $1,000 per year PPT. These are very general estimates. Prior to purchasing PTT's, several topics must be discussed with the manufacturer including size, weight, and attachment applicability, as well as duty cycles and sensor data (see below).

Virtually all PTT's designed for wildlife tracking have the ability to be preprogrammed to transmit (on) and sleep (off) over intervals of varying length. This capability is termed "duty cycle," and it is used primarily for conserving battery power. For example, programming a PTT to transmit 8 h and then sleep 16 h will extend the PTT lifetime approximately three-fold, while still providing locations on a daily basis. Using a weekly duty cycle (e.g., 8 h on/64 h off) will typically extend PTT lifetime over a year or more. Further, many manufacturers offer seasonal duty-cycle capabilities, where the PTT may be programmed to transmit more intensively during months when detailed tracking is desired and then switch to a less intensive duty-cycle to conserve battery life when fewer locations are required (e.g., wintering areas). It should be noted that solar-powered PTT's are manufactured and have performed very well on some animals in suitable climates.

Many satellite transmitter designs have the ability to collect ancillary sensor data about an animal's behavior or environment. A few of the more common sensors used today transmit information about temperature, activity, and atmospheric pressure. For example, for a PTT attached by abdominal implant, temperature data can be used to indicate mortality. For the external collar-attachment used on polar bears, temperature indicates when a female enters and departs a maternity den. Animal activity is typically monitored with a mercury tip-switch. Microprocessors within the PTT usually summarize the activity counts over intervals of time, for example, cumulative 24h totals, or a series of 1h intervals that can be used to study diurnal activity patterns. Pressure transducers can provide information about the altitude of flying birds or the depths attained by aquatic animals. Saltwater switches are used in marine environments to attain information about dive duration as well as prohibit the PTT from pointlessly transmitting while under water. Recently, Global Positioning System (GPS) receivers have been incorporated into some of the larger, more expensive PTT designs, in which case, the calculated GPS location is relayed to the satellite in the form of sensor data. In all cases, sensor data are embedded in each transmission to the satellite. Sensors add varying amounts of weight and cost to a PTT.

Service Argos receivers are flown aboard the National Oceanic and Atmospheric Administration (NOAA) polar-orbiting weather satellites. The NOAA always maintains two operational satellites. Both satellites provide global coverage on a daily basis: one during the morning hours, one during the afternoon, and both with their respective nighttime orbits. At a site on the equator, combined satellite coverage would result in approximately 4-8 PTT locations per full 24 h day. Since every satellite orbit converges at the Earth's poles, coverage increases with latitude. Understanding the NOAA satellite orbitography is necessary for determining when satellite coverage will be available for a study area. This information should be used to optimize a PTT's duty cycle to coincide with diurnal periods of satellite coverage, since no locations can be calculated, and battery power is only wasted if the PTT transmits to an empty sky.

Determining if the Argos satellite tracking system has adequate locational accuracy to meet study objectives is a scale-dependent question. In general, the Argos system should be considered to provide wildlife tracking locations with about 1 km of accuracy. For continental and regional-scale studies, this accuracy is usually acceptable. As study objectives become finer-scale, such as specific habitat utilization, a user should consider recent developments in GPS technologies for wildlife tracking. Service Argos provides an index of quality with each location. Owing primarily to lower output power, the real accuracy for wildlife transmitters is about 50% less than the published Argos estimates for "standard quality" locations. Important to many wildlife studies are the Argos "auxiliary quality" locations, which are based on two or three received transmissions per satellite overpass. These locations vary widely with respect to

accuracy. The best indicator of accuracy or plausibility is to have "redundant" locations, that is, more than one location for an animal in the same vicinity during a relatively short period of time. This strategy can be enhanced by subscribing to the Argos "Multi-Satellite Service," which for a modest cost will provide locations from more than two satellites during periods when NOAA has older satellites in active status.

Systematic data collection by satellite can rapidly generate large volumes of data with varying degrees of locational quality. The author of this abstract has written several SAS programs to ingest raw Argos data formats, summarize the information into ArcView compatible format and flag suspicious or implausible locations. Please contact the author if you are interested in obtaining the current "beta" SAS programs.

National Biological Information Infrastructure/ Federal Geographic Data Committee Metadata: Adding Value to Biological and Spatial Data Sets

Jennifer Gaines, USGS, Office of Biological Informatics; and George Lienkaemper, USGS, Forest and Rangeland Ecosystem Science Center

Have you ever tried to use data from other agencies, organizations, or your own office and ended up contacting the originating office or person to get additional information about the data, such as units of measure, acronyms, map projection, or methodology? In other cases, was it impossible to get the needed information about a data set because the person with the knowledge was no longer involved with the data and there was inadequate documentation?

If you have invested staff, time, and money to create a data set, don't let your data lose value! Metadata extends the value of data beyond a project or person by providing detailed information about the data set. In addition, increase your data set value by serving these metadata through the Web-based, fully searchable National Biological Information Infrastructure (NBII) clearinghouse at http://www.nbii.gov/clearinghouse.html.

Presentations in this half-day workshop laid the foundation for a better understanding of metadata concepts and provided participants with hands on experience using the federal geospatial and biological metadata standard and explored the NBII clearinghouse. The workshop included an introduction to the following:

- Explained the history and background of the NBII Biological Data Profile and Federal Geographic Data Committee's (FGDC) Content Standards for Digital Geospatial Metadata.
- Identified the main structural components of the standard.
- Entered information about participant data sets into specific elements of NBII and FGDC metadata standard using MetaMaker, a metadata collection tool.
- Discussed other metadata collection tools available, in addition to MetaMaker.
- Conducted data set searches in the NBII clearinghouse.

Poster Abstracts

A Sampling of Ecological and Sociological Research in National Parks and Protected Areas of the Pacific Northwest

Robert A. Norheim, USGS, Forest and Rangeland Ecosystem Science Center

The Cascadia Field Station conducts a wide variety of both ecological and sociological research, from user surveys to satellite image analysis and spatial modeling. Geospatial technology supports much of this research. This poster described five of these projects and displayed maps that supported the projects.

Assessing Tropospheric Ozone in Western Washington

This study characterized the distribution of ozone in western Washington. Weekly average ozone concentrations were higher with increasing distances from the urban core and at higher altitudes. The presence of higher ozone concentrations downwind of large cities indicates that ozone and ozone precursors are being transported eastward toward rural wild land areas by prevailing westerly winds. These data provide insight on large-scale spatial variation of ozone distribution in complex terrain and can be used to locate areas with greatest ozone exposure.

Traditional Use of Cabins in the North Additions to Denali National Park and Preserve

Local rural communities have traditionally claimed rights for subsistence users of American public lands. These maps document individual use claims at present and during the 1920's for fur trapping areas in what is now Denali National Park and Preserve.

National Park Service Northwest Region Vegetation and Landform Database

In 1992, the Natural Resource Preservation Program of the National Park Service provided funding to develop and produce a comprehensive geographic information system (GIS) vegetation land cover and geomorphologic landform database for four national parks in the Pacific Northwest Region: Olympic, North Cascades, Mt. Rainier,

and Crater Lake National Parks. The study was designed to develop a comprehensive, consistent inventory and mapping of the vegetation and landform characteristics for the four parks using digital Landsat Thematic Mapper satellite imagery and field-collected data as the primary information bases.

Developing National Spatial Data Infrastructure and a National Biological Information Infrastructure Clearinghouse Node for the Olympic Peninsula

We are developing a comprehensive database of Federal Geographic Data Committee (FGDC) metadata for biological and geospatial information for the Olympic Peninsula in Washington state, linked to the National Spatial Data Infrastructure (NSDI) and National Biological Information Infrastructure (NBII) clearinghouses. The Olympic metadata clearinghouse node is a single, easy access point through which land managers, scientists, decision-makers and citizens of the Olympic Peninsula can preview and acquire information on natural resources.

Spatial Models of Fire Frequency in the Columbia River Basin

We developed statistical models to predict fire return intervals for forested areas of the Interior Columbia River basin at 1-km resolution by using fire history, vegetation, and precipitation databases. The models predict fire return intervals from 1 to 375 years, and latitudinal and elevational gradients of decreasing fire frequency. They provide data to initialize coarse-scale fire-effects models, but predictions for individual sites should be treated with caution because of the coarse resolution.

Side Scan Sonar in Fisheries Research Activities

Michael J. Parsley, Mindi B. Sheer, Erik Kofoot, and Kevin M. Kappenman, USGS, Western Fisheries Research Center

Side scan sonar will effectively image large areas of riverbed, lakebed, or seabed and can also be used to image objects, including fish on or near the substrate and within the water column. Imagery derived from a 600 kHz side scan sonar system operated in the Columbia River is used for several purposes, including previewing bottom trawling sites for potential snags, identifying new areas that could be fished with a bottom trawl, and creating geospatially referenced mosaics of the riverbed for substrate classification.

Testing is also being done to determine if the side scan sonar system can be used to estimate densities of white sturgeon (*Acipenser transmontanus*) in various habitats. We presented a poster that describes how we use side scan sonar in our research activities and displays three acoustic images that characterize our work. The first image depicts an area about 122 m by 100 m of prominent rolling sand dunes. This image illustrates how side scan sonar can be used to characterize the geology of a riverbed and provide a mosaic of a localized area of the reservoir. The second image depicts our use of imagery to preview a potential trawl site for snags. We towed the side scan sonar through a potential trawl site and obtained an image of the riverbed. Conspicuously evident within the image is an object that protrudes above the river bottom that could cause damage to a trawl pulled through the area. The third image was taken while towing the side scan sonar along a setline used for white sturgeon population estimates. Clearly visible within the image are the riverbed, the rope from a setline fished near the river bottom, and two white sturgeon hooked on the setline. The first two images illustrate how side scan sonar can be successfully implemented to meet the needs of fisheries researchers, and the third image suggests possible future applications of this technology.

Using Spatial Tools to Reconstruct the Glacial Chronosequence at Glacier Bay National Park, Alaska

Elizabeth K. Solomon and Philip N. Hooge, USGS, Alaska Biological Science Center

"Spatial tools" is an extension that we have created to expand the capabilities of Spatial Analyst, the raster geographic information systems (GIS) module for ArcView. Spatial tools is a collection of functions made available through ArcView's graphical user interface. Menus, tools, and buttons provide user-friendly access to numberous spatial modeling and analysis functions such as geometric transformations, mosaicking, resolution alteration, and data clean-up and spatial analysis. To demonstrate these tools, we presented a coverage that analyzes the dramatic retreat of ice in Glacier Bay, Alaska, since 1700. This ice coverage provides a base layer to elucidate patterns of primary succession and colonization that have occurred during the period of glacial retreat. Data were synthesized from varying sources, including records from ecological studies and trimline surveys, historic maps and archived information, USGS topographic maps, nautical charts, and Thematic Mapper (TM) satellite images.

(The authors were provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Columbia Basin Salmonid Migration Assessment Tool: BIGSAM—A Regional Spatial and Temporal Information System

Robin M. Schrock, Mindi B. Sheer, Robert E. Reagan, and Jennifer Coyle, USGS, Western Fisheries Research Center

Columbia basin salmonids migrate over great geographic distances. Early life history events and environmental factors affect physiological development, migration behavior, and survival. Life history characteristics of wild and hatchery fish, including species and stock information, rearing and river conditions, and adult returns of Columbia basin salmonids are presented in an assessment tool that describes the complex spatial, temporal, environmental, and physiological interactions of the salmonid migration. An understanding of the spatial and temporal aspects of salmonid life history, as influenced by both physical and seasonal changes in the environment, is necessary to explain annual variation in the juvenile migration and adult returns. The biologically integrated, geospatial salmon access management tool (BIGSAM) references ecological data for Columbia River basin salmonids. BIGSAM provides a searchable, geospatial database framework that incorporates temporally explicit physiological and environmental attributes related to the life history of specific stocks of salmonids. An interactive CD-ROM consisting of the compiled database and an interface for easy, geographically oriented access to temporally defined data will be produced. Links will be provided to regional fishery databases. Creation of this tool will be the foundation for future development of a Web-based publicly accessible Columbia River basin salmonid database. By combining the available data into a single framework, a cumulative salmonid life history data database can be created. The assessment tool will provide fishery managers and researchers with site-specific physiological data with associated environmental conditions throughout the in-river migration. Date, location, species, and stock-specific information for the past decade expand the tool to provide managers with background data for informed decisions.

Analysis of Radio-Telemetry Data: Integrating Salmonid Movement and Migrational Behavior With Physical Conditions in the Lower Columbia River

Mindi B. Sheer, Rachel E. Wardell, Glen S. Holmberg, Jill M. Hardiman, Timothy D. Counihan, Noah S. Adams, and Dennis W. Rondorf, USGS, Western Fisheries Research Center

Hydroelectric development has altered physical conditions in the Columbia River Basin. Consequently, juvenile salmonids incur significant mortality during their migration from fresh water to the ocean as they pass through numerous dams on the Columbia and Snake Rivers. In an effort to recover endangered and threatened salmonid stocks in the Columbia River Basin, managers are reassessing past water management strategies. Understanding the behavior of seaward migrating salmonids will help managers determine river discharge and dam operation scenarios that may improve juvenile survival.

The Columbia River Research Laboratory has been using radio telemetry to evaluate fish movement and behavior on the Lower Columbia River since 1991. Recent studies (depicted in this poster) have focused on radio-tracking in near-dam environments. During outmigration, juvenile salmonids (*Oncorhynchus* spp.) were implanted with radio transmitters and tracked by boats equipped with Yagi antennas and telemetry receivers. Once fish were located, the position was georeferenced using a Global Positioning System (GPS). The spatial distribution of fish positions was used to assist in determining fish travel time, holding patterns, and general behavior. The availability of this detailed spatially referenced data has allowed us to explore correlations between biological and physical riverine parameters and to use a number of innovative techniques to further the analysis of our data. We integrated fish positions with water velocity model data to estimate selected velocities used by juvenile salmonids during dam approach and applied the resultant logistic regression model to predict probabilities of salmon habitat selection. Another study employed collecting GPS transect information on a floating drogue to compare the path of a passive float to active, downstream migration patterns of juvenile salmonids. An acoustic doppler current profiler was also used to obtain water depth and velocity data downstream of the dam and will be used to assess fish travel patterns and to test the accuracy of hydraulic models for the area.

Incorporating Terrain Modeling into Ecological Studies

John Young, Dave Morton, and Craig Snyder, USGS, Leetown Science Center

Terrain (or landform) is an important determinant of many ecological processes. Landform influences air and ground temperatures, moisture regimes, and the amount of nutrients and other materials available to plants and animals. Landforms also influence the flow of materials, organisms, energy, and materials moving through landscapes, and constrain the spread of abiotic disturbances (flood, fire, storm events) that influence biotic distributions. Terrain analysis is therefore an important component of ecological studies that seek to explain the distribution of organisms on the landscape or the correspondence between species and their habitats. Geographic information systems (GIS) provide useful tools for studying the interaction between biota, environmental conditions, and topography. Terrain analysis is

easily accomplished using common GIS software and digital elevation models (DEM) available from the U.S. Geological Survey (USGS). However, many researchers seldom stray beyond the common applications of terrain analysis such as calculations of slope, aspect, or shaded relief (e.g., hillshade).

This poster described methods used by the staff of the USGS Aquatic Ecology Laboratory to incorporate terrain modeling into ecological research. In a study of the relative influence of land use on fish community structure, we created watershed boundaries above points sampled for fish and habitat, and used these catchment boundaries as the basis for data summaries. For a study of eastern hemlock decline in Shenandoah National Park, we are examining the interaction between terrain features and spectral reflectance in order to more accurately map hemlock forests. One method we are exploring is the use of principal components analysis to highlight the main components of terrain in our study area. In a study of possible effects of eastern hemlock (*Tsuga canadensis*) decline on aquatic insect and fish communities at Delaware Water Gap National Recreation Area, we developed a terrain-based stratification and pairing sample design based on statistically derived estimates of topographic similarity. In preparation for this study, we analyzed several terrain-based GIS layers thought to strongly influence stream habitat conditions. These layers were elevation, slope, aspect, landform, solar illumination, stream order and length, and forest type. We used this information to match pairs of sites with similar topography but with different forest cover types and tested for differences in biota.

We are continuing to explore new methods for extracting information from terrain models for use in ecological assessments, modeling, and vegetation mapping. For example, we are investigating phenological models based on DEM's that can be used for vegetation mapping and Classification and Regression Tree (CART) models that provide the ability to classify and predict a biotic response based on terrain variables.

Development of a Decision Support System for John Day Reservoir

David E. Rupp, James Guyton, Mindi B. Sheer, and Michael J. Parsley, USGS, Western Fisheries Research Center; and Carl Korschegen, USGS, Upper Midwest Environmental Sciences Center

Anadromous salmonids in the Pacific Northwest are in decline, and several species and stocks have been listed as threatened or endangered. Thus, resource managers are proposing drastic and radical changes to the hydrology and water levels on the Columbia and Snake Rivers. Alternatives will be developed which will benefit salmonids but which will also have secondary impacts on other fish and wildlife resources in the Columbia River. The U.S. Geological Survey's Western Fisheries Research Center (WFRC) and the Upper Midwest Environmental Sciences Center (UMESC) are collaborating to build a spatial decision support system (DSS) which planners and managers can use for assessments of salmonid survival and management options for the aquatic and terrestrial resources. The centers have unique capabilities that are being combined to provide resource managers with information that can be used to determine the impacts of the proposed water level manipulations. Staff at the WFRC will provide expertise on hydraulic modeling and fishery impacts of the proposed actions, and UMESC staff will provide expertise on terrestrial ecology and wildlife impacts.

John Day Reservoir was created on the Columbia River in 1968 for power generation, navigation, flood control, and irrigation. The reservoir is approximately 80 mi in length, and water levels in the forebay of John Day Dam fluctuate about 11 ft under current operating conditions. However, fisheries managers are proposing permanently drawing the reservoir down by as much as 100 ft in an effort to improve survival of endangered anadromous salmonids. The lowered water levels are expected to increase water velocities within the reservoir and to restore normative riverine functions to the upper portion of the reservoir under partial drawdown, or to the entire river under a drawdown to natural river levels. The increased water velocities are expected to reduce the time it takes for outmigrating juvenile salmonids to reach the estuary. It has also been suggested that predation on juvenile salmonids will be reduced because encounter rates with predators will be reduced.

Water level manipulations will affect upland and wetland habitats bordering the reservoir. Specifically, water level drawdowns will have significant impact on the operation and management of the 23,555 acre Umatilla National Wildlife Refuge (NWR). The Umatilla NWR was established in 1969 as a mitigation project for the impacts of flooding caused by hydropower development. There will be a need to develop a new management plan for this refuge if water levels within the reservoir are lowered.

By building a DSS framework for this assessment, we will meet many needs of policy makers and resource managers by providing mapping capability of land and biological resources, a common digital database for information, a suite of spatial analysis tools, display of predictive model output, and a basis for land management alternatives. The system will provide for the integration of biological and physical themes so that decisions can be made with the best available science

and data. The digital atlas will provide for the creation of a variety of digital and paper products.

(The authors were provided the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Combining Landsat Thematic Mapper Imagery with Terrain Variables to Map Eastern Hemlock (*Tsuga canadensis*) in Shenandoah National Park

David D. Morton, John A. Young, and
Nissa M. Thomsen, USGS, Leetown Science Center

Hemlock woolly adelgid (*Adelges tsugae*) is a small twig boring aphid-like insect known to defoliate eastern and Carolina (*Tsuga caroliniana*) hemlock trees. This exotic pest was first observed in Shenandoah National Park in the mid-1980's. Since then, the adelgid has expanded its range throughout the park. Most stands were heavily defoliated within several years of infestation. However, several hemlock stands appear to be not affected or only moderately affected to the present date. To investigate this discrepancy in hemlock stand condition, we are analyzing rates and intensity of defoliation using satellite imagery from 1984, 1988-89, 1991-92, 1994, and 1997. The ultimate goal is to provide a model to predict future infestations.

The first step is to map the initial extent of hemlock stands, using the earliest available imagery (1984). This map is crucial because it will act as a "mask" defining the extent for future analyses. We are investigating the combination of topographic factors, such as relative phenology, slope, northness (aspect), and landform index, with spectral reflectance from Landsat Thematic Mapper (TM) imagery to delineate hemlock from other coniferous forests. Field visits supplemented with aerial photographs and expert knowledge will be used as ground reference and accuracy assessment information.

The next step is to use an appropriate vegetation index to represent hemlock health for each time period. Differences in health from year to year can then be quantified. The rate and intensity of defoliation will be analyzed spatially.

The results of the spatial analysis will be related to patterns within the landscape and at the stand. Factors such as climate, moisture availability, wind direction, nearness to trails, stand density, and tree size will be evaluated for relationships with defoliation events. The ultimate goal is a model for hemlock stand vulnerability.

Creating a Geographic Information Systems Database for the Gulf Coast Joint Venture

Matt Phillips, Johnson Controls World Services Inc., Barataria-Terrebonne National Estuary Program; and
Barry Wilson, Gulf Coast Joint Venture

The Gulf Coast Joint Venture (GCJV) provides a forum for government agencies, conservation organizations, and private landowners to coordinate activities and pool resources to accomplish Gulf of Mexico coastal wetland conservation. These activities are for the primary purpose of restoring wetlands to support continental waterfowl populations as outlined in the North American Waterfowl Management Plan. Geographic information systems (GIS) can be valuable tools for GCJV planning. For example, GIS can assimilate spatial data that are likely to be important for future waterfowl management in the region. With this in mind, we created an initial database by acquiring coverages from federal, state, and nongovernment online data clearinghouses as well as from data resources within the U.S. Geological Survey's National Wetlands Research Center. So far, this database has allowed the GCJV to assess relative distribution of managed wetland sites, sanctuaries, and rookeries; bathymetry of shallow bays with high foraging potential; and access points (i.e., boat ramps) which may index potential disturbance. The GIS will be updated and expanded as the GCJV progresses. As biological plans are more fully developed and as new research dictates new aspects of planning, GIS models will be developed to target sanctuary restoration and management.

Application of Satellite Telemetry to Identify Habitat Use by the Midcontinental Population of Sandhill Crane Throughout the Annual Cycle

Gary L. Krapu and David A. Brandt, USGS, Northern Prairie Wildlife Research Center

The midcontinental population of sandhill crane (*Grus canadensis*) consists of about 500,000 birds and three subspecies, that is, the greater sandhill crane (*G. canadensis tabida*), the Canadian sandhill crane (*G. canadensis rowani*), and the lesser sandhill crane (*G. canadensis canadensis*). The breeding and wintering grounds, migration routes, and staging areas for each of the three subspecies are poorly defined. As a result, crane managers currently are hampered by a lack of information when they try to prioritize focus areas for habitat conservation and restoration and address other management issues concerning the midcontinental population.

The recent development of small, lightweight platform transmitting terminals (PTT's) that can be tracked from orbiting satellites has greatly expanded opportunities to gather detailed scientific information on birds. This new technology has practical application for addressing key management needs of the midcontinental sandhill crane population. Scientists at the U.S. Geological Survey's Northern Prairie Wildlife Research Center are working closely with the U.S. Fish and Wildlife Service and states

in the Central Flyway in applying satellite telemetry technology to delineate distribution and habitat use by each of the three subspecies of cranes throughout the annual cycle. As part of these studies, researchers are determining habitat characteristics in areas occupied by the subspecies on their breeding grounds in Canada, Alaska, and Russia by using Advanced Very High Resolution Radiometry (AVHRR) satellite imagery. This information will be used to help crane managers gain a better understanding of breeding habitats selected, thereby providing greater insight into the needs of the midcontinental population across the vast and remote regions where breeding occurs.

Sandhill cranes are captured during spring migration in Nebraska by using decoys to attract birds to sites where they can be caught with rocket-propelled nets. A 30-gram transmitter attached to a plastic leg band is placed on the upper leg of each bird. One bird is radio-marked per successful capture attempt. Upon release, the PTT-marked cranes are tracked by orbiting weather satellites which relay information to ground locations.

Eleven PTT-marked cranes trapped and marked during 1998 and 1999 spent the breeding season in Canada within the area covered by the classified landcover image. The four satellite-monitored lesser sandhill cranes occupied habitats near the coast or on islands in landscapes dominated by lichens and low lying shrubs with some component of evergreen forests, a characteristic of the tundra regions and transitional zones between the boreal forest and tundra. The seven satellite-monitored cranes of the Canadian subspecies were distributed from near the MacKenzie River Valley in the western Northwest Territories to eastern Ontario and generally occupied a mosiac of classified forests (evergreen and deciduous) and agricultural lands. When collapsed across individuals and regions of interest, tundra and transition zone cover types made up 26 times more of the classified habitats associated with lessers than the Canadian subspecies. No individuals of the greater subspecies were monitored during 1998 and 1999.

This work, when completed, will provide greater insight into the breeding distribution and habitats occupied by the midcontinental population of sandhill cranes during the nesting season along with distribution and habitats occupied during the remainder of the year. This information will provide crane managers with improved insight for pinpointing where to focus habitat conservation efforts and to better assess impacts of environmental change.

Use of Photointerpretation and a Geographic Information System to Develop a New Approach to Restoration and Management of a Lake Erie Coastal Wetland

Kurt P. Kowalski and Douglas A. Wilcox, USGS, Great Lakes Science Center

An innovative restoration plan was developed for Metzger Marsh, a degraded Lake Erie coastal wetland formerly protected by a barrier beach. High water levels, storm events, and limited sediment supply contributed to the destruction of the barrier beach. The restoration approach is based on analyses of geospatial and ecological data and seeks to restore wetland plant communities by recreating a system that functions in a manner similar to predevelopment conditions.

A photointerpretation study of aerial photographs dating from 1940 to 1994 was conducted to develop an understanding of the relationships between wetland condition, water-level fluctuations, and status of the barrier beach at Metzger Marsh. The boundaries of major plant associations, open water, and other land features were delineated onto clear acetate overlays and digitized into ARC/INFO geographic information systems (GIS) software (ESRI, Redlands, California). Trimble Differential Global Positioning System (DGPS) equipment was used to calculate precise positional data, guide groundtruthing exercises, and simplify the georeferencing of GIS coverages. ArcView GIS software (ESRI, Redlands, California) supplemented the ARC/INFO software by providing a simple mechanism for simultaneously viewing multiple data sets, conducting basic areal and distribution analyses, and producing detailed hardcopy maps.

Analyses revealed that Metzger Marsh was once a drowned-river mouth wetland and protected by a sand barrier beach. Extremely high water levels, storm events, and a reduction of sediments in the littoral drift contributed to the complete destruction of the barrier beach in the early 1970's and a subsequent reduction in the amount of wetland vegetation in the marsh. Because of a lack of adequate sediment supply and a low probability of extremely low water levels, federal and state managers decided to construct a dike to replace the protective barrier beach. A water-control structure was incorporated into the dike to allow the exchange of water, sediments, and biota between the marsh and Lake Erie, similar to the natural opening in the beach observed in historical photographs. The protective dike and water-control structure allow the marsh to be managed in a manner that mimics historical conditions.

Hyperspectral Analysis of Multitemporal Landsat Thematic Mapper Data for Mapping Fuels in Yosemite National Park

Ralph Root, USGS, Center for Biological Informatics; and Jan van Wagtendonk, USGS, Yosemite Research Center

In recent years, wild land fires have become more intense, resulting in increased loss of life and resource damage. Critical to resolving this problem is better information on the amount and condition of fuels on the ground. With this information, fire managers can better predict potential fire behavior, make more informed tactical and strategic decisions, and plan and conduct fuel treatments.

We examined the use of multitemporal Landsat Thematic Mapper (TM) imagery for developing a technique for identifying fuel types based on season changes in plant phenology. Six orthocorrected and registered TM scenes representing approximately 1-month intervals during the 1992 growing season are being examined using hyperspectral analysis.

Using temporal sequences, changes in annual grasslands, for instance, can be traced as the grasses green up in the spring and cure during the summer. This fuel type can thus be distinguished from alpine meadows which cure at a different rate. Similarly, deciduous hardwood fuels which drop to the ground in the fall are differentiated from evergreen hardwoods which retain their leaves.

We used single-scene TM images to classify fuels in the past. Maps produced from this analysis were used to predict the behavior of two large wild land fires that were being allowed to burn to meet resource objectives, to plan for extensive prescribed fires set by managers, and to make tactical decisions on a wild land fire that was being actively suppressed. In each case, operations were enhanced by the availability of information on fuels. The analysis of temporal data should increase the accuracy of the resultant maps.

As Landsat 7 data become available, additional information on forest fuel conditions should become discernible. This information will be incorporated into enhanced mapping techniques. With accurate fuels information in hand, fire managers should be able to make informed decisions about ongoing wild land fires and fuel treatments. These decisions will result in safer conditions for firefighters and less resource damage.

Wetland Reserve Program Decision Support System

Steve Hartley, USGS, National Wetlands Research Center; Antonio Martucci, Johnson Controls World Services Inc., National Wetlands Research Center; and James B. Johnston, USGS, National Wetlands Research Center

The Lower Mississippi River Valley (LMRV) has experienced dramatic forested wetland losses (over 80%) in the last century as a result of clearing for agriculture and urban expansion. Federal and state efforts are oriented towards promoting wetland conservation and restoration programs that preserve these valuable resources for future generations. Advanced spatial analysis techniques, that is, decision support geographic information systems (GIS), improve the resource manager's capability of defining potential sites for wetland restoration or conservation. Partners of this project are the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Alexandria, LA; U.S. Fish and Wildlife Service, Ecological Services Office, Lafayette, LA; The Nature Conservancy, Baton Rouge, LA; and U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA.

Wetland Reserve Program (WRP) is a voluntary program designed to restore and protect wetlands located on private property. It is administered by the USDA's NRCS, in consultation with the Farm Service Agency and other federal agencies. Landowners who enter the program receive financial support to take their marginal agricultural land out of production for conversion to wetlands or enhancement and/or for protection of existing wetlands. The ultimate goal of WRP is to enroll under the program about 1 million acres nationwide. The states of Tennessee, Louisiana, Mississippi, and Alabama will benefit most from this program.

Using Environmental Systems Research Institute ArcView 3.0a GIS software, an application was developed to organize the available data sets and allow land resource managers to access sophisticated display and analysis tools without being GIS experts. ArcView, combined with Avenue scripting language, offers the possibility of integrating and visualizing geographic and tabular data into a complete analysis system while creating a highly user-friendly Windows environment. The ease of usage was considered a primary goal because, unfortunately, managers rarely use GIS for decision making because of its prohibitive cost (hardware and software) and learning curve.

ArcView Graphical User Interface (GUI) has been customized for this project by incorporating menus, menu items, buttons and tools icons. Land resource managers can use these display and analysis tools without the extensive training associated with GIS. The GUI also allows the user to select information layers, open display windows, and perform some complex and multiphase tasks in one or more steps. Input and selection message boxes guide the user to complete processes successfully.

In closing, GIS is a technology that allows the assembly, storage, manipulation, display, and output of

geographical and related tabular data. Investigations and analyses on different but geographically related data sets may be performed by using overlay or query techniques. Additionally, GIS can use different types of data and information from different sources and in different forms. The primary purpose of the GIS application is to present geographic and tabular data in one comprehensive, easy-to-use application. This WRP application incorporates those capabilities which enable the user to better use and analyze incoming environmental data with existing data sets.

Use of Geographic Information Systems, Remote Sensing, and Radio Telemetry in the Snake River Birds of Prey National Conservation Area

Tom Zarriello and Steve Knick, USGS, Forest and Rangeland Ecosystem Science Center; and Linda Schueck, Boise State University

We used geographical information systems (GIS), remote sensing, and radio telemetry (VHF and satellite-received) in a multiyear, multi-investigator project conducted in the Snake River Birds of Prey National Conservation Area from 1990-95. The subsequent U.S. Bureau of Land Management (BLM) and the Idaho Army National Guard research project final report "Effects of Military Training and Fire in the Snake River Birds of Prey National Conservation Area" was completed in December 1996. The objective of the five component study was to determine the influence of wildfires and military training on habitats, prey, and raptors. Our studies focused on spatial and temporal variation in habitat use by foraging raptors and habitat characteristics associated with principal prey species. A vegetation map, classified from satellite imagery, was used in modeling habitat relationships of black-tailed jackrabbits, prairie falcons, golden eagles, and five species of passerine birds. Using change detection analysis of multitemporal satellite imagery, we demonstrated that the greatest changes in land cover were associated with combinations of disturbances. By simulating spatial and temporal vegetation dynamics, we projected that almost all shrubland would be lost within 40 years if current conditions are continued. Alternatively, restoration of shrublands lost since 1979 may take almost 100 years in the absence of active restoration efforts. These cooperative studies were funded jointly by the BLM and the Idaho Army National Guard. The former U.S. National Biological Service and the U.S. Geological Survey's Forest and Rangeland Ecosystem Science Center provided additional funding and support.

Using Geospatial Technology to Identify Streams Supporting Isolated Populations of Coastal Cutthroat Trout

Robert E. Gresswell and George W. Lienkaemper, USGS, Forest and Rangeland Ecosystem Science Center; and Douglas S. Bateman, Oregon State University

There is growing consensus that knowledge of the form, function, and historical context of landscapes is essential to the research and management of ecosystems at a variety of spatial scales. The Northwest Forest Plan (NFP) is based, in part, on attempts to manage federal lands within the range of the northern spotted owl at the landscape level, and recently proposed management plans for state forest lands in western Oregon are directly linked to hypothesized responses of organisms to patterns at large spatial scales. These approaches rely heavily on theoretical ecology, landscape ecology, and metapopulation theory, but much of the information necessary to implement the new management strategies is lacking. In an effort to investigate interactions of coastal cutthroat trout (*Oncorhynchus clarki clarki*) with aquatic habitat at numerous spatial scales, we sought to identify populations that were isolated above natural barriers to anadromous fishes. Initially, third-order watersheds west of the Cascade Mountain divide were delineated by using 30-m digital elevation models at the 1:24,000 map scale and tools from the U.S. Geological Survey (USGS) geographic information systems (GIS) Weasel application. A database that provides the location of barriers to upstream fish movement was developed by using information obtained from the Oregon Department of Fish and Wildlife database and from interviews with field biologists from numerous state and federal agencies. A total of 285 isolated watersheds were identified. Because we expected physiographic province and geology to be important explanatory variables, these isolated watersheds were divided into one of three ecoregions: Coast Range, Klamath, and Cascade, and then into one of two erosion potential classes based on igneous (higher erosion potential) or sedimentary (lower erosion potential) rock types. By linking the three GIS data layers (watersheds, migration barriers, and ecoregion erosion potential), we found 278 third-order watersheds above barriers to anadromous salmonids that supported isolated populations of cutthroat trout. We used proportional stratification to randomly select 60 basins from the six physiographic/geologic categories for habitat evaluation and population assessment. The resulting database is being used to investigate distributional patterns of isolated populations of cutthroat trout at spatial scales ranging from local (channel units) to regional (western Oregon).

Modeling the Distribution of Neotropical Birds Throughout the Americas

Ian Thomas, APL Inc., Patuxent Wildlife Research Center

This poster assessed the geographic information system (GIS) model and data layers used to create individual Neotropical bird species distribution maps from habitat data contained in the Ecological and Distributional Databases in "Neotropical Birds: Ecology and Conservation," by D.F. Stotz, J.W. Fitzpatrick, T.A. Parker III, and D.K. Moskovits.

(The author was given the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

A New National Mosaic of State Landcover Data

Ian Thomas, APL Inc., Patuxent Wildlife Research Center

This poster reviewed current landcover mapping efforts and presented a new preliminary national mosaic of Gap Analysis Program (GAP) and Multi-Resolution Land Characteristics (MRLC) Consortium landcover data, with a discussion of techniques, problems faced, and future refinements.

(The author was given the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Use of Remote Sensing Techniques to Survey the Physical Habitat in Large Lakes and Rivers

Gregory W. Kennedy and Thomas A. Edsall, USGS, Great Lakes Science Center

Remote sensing techniques can be used to quantitatively characterize the physical habitat in large lakes and rivers. Traditional survey techniques typically used in small, shallow water bodies are difficult or impossible to apply effectively to large rivers and lakes. The state-of-the-art remote sensing technologies that we discussed here include side-scan sonar, RoxAnn, acoustic doppler current profiler, remotely operated vehicles and underwater camera systems, and satellite positioning systems. The use of these technologies will permit the collection of information needed to create computer visualizations, hard copy maps, and quantitative databases that can be used in real-time mode in the field to characterize the physical habitat at a study site of interest. The results of these quantitative assessments will be used to more effectively, and efficiently, guide the distribution of sampling efforts needed to address other habitat-related study objectives.

Vegetation Mapping of St. Vincent National Wildlife Refuge

Arturo Calix, Sue Grace, and Lawrence Handley, USGS, National Wetlands Research Center; and Rosemary Mouton, Troy Barrilleaux, and Jesse Thibodeaux II, Johnson Controls World Services Inc., National Wetlands Research Center

Natural resource management staff at the U.S. Fish and Wildlife Service (USFWS), St. Vincent National Wildlife Refuge determined the need for an updated map of plant communities on the island. The U.S. Geological Survey's National Wetlands Research Center developed a vegetation map from 1:32,500 scale color infrared aerial photography acquired in December 1992. The map is a useful and an important component of a geographic information system (GIS) that provides information used in the management of refuge wildlife, fire, hydrology, and recreation.

Monitoring Coastal Wetland Restoration Projects with Geographic Information Systems and Remote Sensing Technology

William R. Jones, USGS, National Wetlands Research Center

Over the past several decades, coastal Louisiana has experienced a considerable loss of its natural wetlands. In 1990 the United States Congress authorized the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) in part to conserve, create, restore and enhance Louisiana's coastal wetlands. The CWPPRA monitoring plans are developed and implemented with a comprehensive approach to long-term conservation. The U.S. Geological Survey's National Wetlands Research Center and the Louisiana Department of Natural Resources (LDNR) are responsible for monitoring approximately 109 projects in coastal Louisiana that have been implemented through CWPPRA. All projects are categorized into nine design types: freshwater diversion, sediment diversion, marsh management, hydrologic restoration, beneficial use of dredged material, shoreline protection, barrier island restoration, vegetative planting, and sediment and nutrient trapping. Projects designed under this program range from large freshwater diversion and hydrologic restoration to smaller scale vegetative plantings and shoreline protection. Geographic information systems (GIS) analyses are performed on habitat data generated from high resolution color infrared photography that has been photointerpreted according to vegetation types. In addition to the GIS analysis,

remote sensing techniques are used to depict land loss and land gain rates from scanned and rectified aerial photography. Aerial photography is georectified with field-collected ground-control points by using a Global Positioning System. Other acquired data layers, such as water salinity, water elevation, soils, and tidal fluctuations, are synthesized with the interpreted habitat and land-water data to provide a better understanding of the environmental conditions for each project. All projects are monitored during their 20-year lifespan. The linkage of spatial information with temporal data provide managers with the necessary tools to evaluate the effectiveness of wetland restoration at very large scales.

Mobile Bay Habitat Change: 1956-88

Lawrence R. Handley, William Jones, and James B. Johnston, USGS, National Wetlands Research Center; and Laurie Marien, Johnson Controls World Services Inc., National Wetlands Research Center

The U.S. Geological Survey's (USGS) National Wetlands Research Center (NWRC) in partnership with the U.S. Environmental Protection Agency's (EPA) Gulf of Mexico Program, the U.S. Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI), the Daphne, Alabama Ecological Services Office, and the Alabama Department of Economic and Community Affairs have completed a status and trends poster for the Mobile Bay estuary wetland and upland habitat for 1956, 1978, and 1988. The wetland and upland interpretation was from mid-1950's black and white 1:20,000 scale aerial photography, and the 1978 and 1988 delineations were from color infrared, 1:65,000 scale aerial photography. The wetlands were classified by using the accepted national federal standard wetland classification system, "Classification of Wetlands and Deepwater Habitats of the United States." The uplands were classified by using the USGS Anderson classification modified for upland habitat delineation. Thirty 1:24,000 scale USGS quadrangles were interpreted and mapped. The photo-interpretation was groundtruthed by personnel from the USFWS NWI, the Daphne, Alabama Ecological Services Office, and the USGS's NWRC. All maps were reviewed by state, federal, and local agencies within the Mobile Bay area. The habitat maps were digitized; the digital data are available from the USGS NWRC, and the 1988 wetland data are available from the USFWS NWI.

Mapping Essential Federal Geographic Data Committee Metadata Into MARC21 and Dublin Core

Dan Foley, Adam Chandler, and Aladdin Hafez, Energy and Environmental Information Resources Center

This study addresses a number of issues related to the conversion of Federal Geographic Data Committee (FGDC)-compliant metadata into MARC21 or Dublin Core metadata. Its focus is on conversion issues as they relate to the Online Computer Library Center's Cooperative Online Resource Catalog project. We presented an analysis of 466 FGDC metadata records housed in the National Biological Information Infrastructure (NBII) node of the FGDC clearinghouse, with special emphasis on the length of fields and the total length of records in this set. One of our contributions is a translation of 36 FGDC elements into MARC fields, which takes into consideration the constraints of the MARC21 standard and the realities of user behavior. A second contribution is the discovery that the key to this conversion problem is integrating Persistent Uniform Resource Locators (PURL's) into the FGDC clearinghouse model.

Wetland Education Through Maps and Aerial Photography

Lawrence R. Handley, USGS, National Wetlands Research Center; Catherine Lockwood, Chadron State College; Nathanial S. Handley, National Aeronautics and Space Administration Regional Application Center; and Jean May-Brett, Louisiana Public Broadcasting

Wetland Education Through Maps and Aerial Photography (WETMAAP) is a series of wetland workshops for educators that provides basic ecological concepts, technological skills, and methods of interpretation necessary for understanding and assessing wetland and upland habitat change. Our objective is to introduce wetland habitats and their functions and values to educators. By providing wetland workshops to educators, we hope to increase their abilities to promote student awareness of and interest in wetland issues. Workshop participants will explore wetlands by using aerial photography, satellite imagery, and wetland maps and will learn how to introduce traditional mapping techniques into the classroom. WETMAAP offers a low-cost method of accessing high-tech data and using up-to-date techniques, procedures, and theories for data interpretation and assessment of wetlands. WETMAPP also introduces the concept of geographic information systems (GIS). Workshop participants or website users have the option to reproduce workshop materials at a minor copy price or to print most of the materials from the website. Through use of the WETMAAP (www.rac.louisiana.edu/wetmaap), educators can increase their ability to promote student awareness of and interest in wetland issues.

Historical Forest Cover and Current Reforestation Efforts at the Mollicy Farms Tract, Morehouse Parish, Louisiana

John W. McCoy and Wylie Barrow, USGS, National Wetlands Research Center; Kelby Ouchley, U.S. Fish and Wildlife Service; and Keith Ouchley, The Nature Conservancy of Louisiana

The Mollicy Farms tract consists of approximately 46 km^2 (31 mi^2) of abandoned agricultural fields surrounded by protection levees in northwest Morehouse Parish, Louisiana. Aerial photographs show that the area was forested in 1941, but subsequent clearing for agriculture after 1965 resulted in the elimination of forest vegetation over most of the site. After several farming efforts failed, the land was abandoned and eventually sold to the U.S. Fish and Wildlife Service for restoration of bottomland hardwood forest and for use as moist soil habitat.

Contour maps depicting the woody vegetation of the site were derived from Government Land Office (GLO) records, which indicated 17 historical forest types and 16 groups of tree species. Forest types at the time of the GLO survey included pine (*Pinus* sp.)-oak (*Quercus* sp.), Nuttall oak (*Quercus texana*)-sweetgum (*Liquidambar styriciflua*), and overcup oak (*Quercus lyrata*)-hickory (*Carya* sp.). These three forest types are reduced from the 16 types noted in the GLO records. A forest stand table of relative frequency, dominance, and density of trees was developed. Overcup and Nuttall oak had the highest importance values, whereas pine, sweetgum, and hickory were less well represented. Most of the land is of low elevation and floods, which explains the high number of oaks; however, there were areas of higher elevation where pine trees grew. These data, along with analysis of a nearby forest stand, can be used by land managers to guide restoration attempts on this vast area.

Nourishment of a Disappearing Barrier Island—Raccoon Island, Louisiana

Lawrence R. Handley, Arturo Calix, William Jones, and Steve Hartley, USGS, National Wetlands Research Center; Eric Seeger, Troy Barrilleaux, Rosemary Mouton, Laurie Marien, and Antonio Martucci, Johnson Controls World Services Inc., National Wetlands Research Center; and Greg Linscomb, Louisiana Department of Wildlife and Fisheries

In August 1992, Hurricane Andrew severely impacted the southcentral Louisiana coast and the offshore barrier islands. The eye of the storm passed within 5 mi (8 km) to the west of Raccoon Island. High winds and storm surge eroded more than half of an already threatened barrier. In 1839, Western Isle Dernieres was 32 mi long and over 1 mi wide. By 1956 the island had been reduced to approximately 3 mi long by a quarter of a mile wide. The island is the home for the largest concentration of nesting, wading, and shore birds along the Louisiana coast. The adverse effects of the hurricane on the island generated considerable interest in developing a plan to dredge millions of cubic yards of sand from offshore and pump it onto the island to fill in overwash areas and nourish the beach. Color infrared aerial photography was acquired at a scale of 1:6,000 for the island in November 1993, prior to nourishment action. In February 1994, another set of 1:6,000 scale color infrared aerial photography was acquired after the pumping of the sand. In November 1994, November 1995, December 1996, December 1997, and November 1998, 1:6,000 color infrared aerial photography was acquired to assess the results of the restoration activity. The aerial photography was scanned and mosaicked to provide rectified photo maps of the island to serve as up-to-date base maps for habitat interpretation and shoreline delineation. Field check sites were established on the island for vegetation signature correlation and as ground control points collected with a Global Positioning System (GPS) to be used for image rectification. Each date of the aerial photography was interpreted for wetland and upland habitats, and 1:6,000 scale habitat maps were produced. The maps were digitized and the data analyzed in a geographic information system (GIS) to provide habitat acreage change and shoreline erosion and accretion.

Using Global Positioning System Technology Via Air, Boat, and Ground Surveys to Map and Model Bathymetry of Catahoula Lake, Louisiana

Thomas W. Doyle, Thomas C. Michot, and Christopher Wells, USGS, National Wetlands Research Center; and Tom Hargis and Garrett Girod, Johnson Controls World Services Inc., National Wetlands Research Center

Refuge personnel at Catahoula National Wildlife Refuge in central Louisiana need to know how surface water management practices may be altering the long-term stability and quality of marsh and woody habitat following summer drawdown of Catahoula Lake. Lake water levels are managed in the summer and fall for wintering waterfowl food preference and feeding habits. Recent vegetation surveys suggest that preferred waterfowl plant species are being replaced by less desirable plant types perhaps because of changes in the effect of lake drawdown levels and rates. An adaptive management approach has been proposed to refine the surface water management plan for the refuge to maintain or increase food crop production for waterfowl benefits. Global Positioning System (GPS) technology was used to map contours of lake shoreline and bathymetry prior to

and following the usual summer drawdown from aircraft, boat, and ground observations. A bathymetric survey of Catahoula Lake was accomplished during spring high water using a PC-laptop link of differential GPS location and a depth sounder for recording bottom depth. Soundings were taken every one-tenth of a second along predefined transects of eastings and northings 1 km apart. Global Positioning System technology was used to locate transect starts and to keep boat direction on line. Aerial overflights were conducted to videotape the drawdown of exposed lake bottom and vegetation succession at various stage levels. Global positioning system tracking capability was used to record the shoreline extent at each stage level of drawdown. Ground surveys were conducted with laser level and GPS equipment to link and rectify land and water datums of air and boat source. These collective elevation and geopositional data have been imported into a geographic information system for mapping and modeling purposes. A digital elevation model of the lake bottom will be interpolated to provide a three-dimensional view and to calculate lake coverage in acres at different stage levels of drawdown. This bathymetric model of Catahoula Lake will be correlated with fall surveys of vegetation distribution to construct an ecological simulation model that can be used to test various alternative drawdown rates and levels as a geospatial tool for research and management.

Modeling Climate Change Impacts on the Health and Distribution of Mangrove Communities of South Florida

Thomas W. Doyle, USGS, National Wetlands Research Center; and Garrett Girod and Mark Books, Johnson Controls World Services Inc., National Wetlands Research Center

Predictions about global climate change include increases in sea level and an intensity of tropical storms. Gulf coastal forests are susceptible to direct damage from acute and chronic changes of incremental sea level increases and from forceful storm impacts of wind and surge. Landscape simulation models were developed to evaluate the impacts of increasing water levels and disturbance associated with global climate change on mangrove forests of the Everglades, Florida. A spatially explicit stand simulation model of mangrove forest growth and succession that tracks individual tree establishment, growth, and mortality was hierarchically integrated with multiple landscape-level models of landform and environmental force from sea level and tropical storms. Model applications show that hurricane frequency and intensity have varied spatially across Florida's lower peninsula over the last century. A hindcast simulation for 1886-1989 indicates that the periodicity and trajectories of a few major hurricanes accounted for most of the impact on forest structure of modern day mangrove forests across south Florida. As hurricane intensity increases over the next century, model projections suggest that future mangrove forests are likely to be diminished in average height and will contain a higher proportion of red mangroves. Regional assessment of sea-level rise impacts involved the development of a digital elevation model of Florida's lower peninsula based on available topography contours at 1 ft intervals and marsh/mangrove ecotone proxy elevations. Projected encroachment of mangrove habitat into marsh and upland forests was computed for different scenarios of sea-level rise. This modeling approach offers the ability to assess decadal and longer time scale climate changes in hurricane behavior and sea level on the future fate of regional community structure and distribution of coastal mangrove habitat of south Florida.

The Use of Videography to Assess the Geospatial Impact of Hurricanes on Forest Ecosystems

Thomas W. Doyle and Christopher J. Wells, USGS, National Wetlands Research Center; Ken Krauss, USDA, Pacific Southwest Research Station; and Garrett Girod, Johnson Controls World Services Inc., National Wetlands Research Center

Hurricanes wreak havoc on societies and ecosystems alike. In 1992, Hurricane Andrew ripped through south Florida and left a swath of economic and ecologic disaster in its wake. Forest inventories were conducted before and after Hurricane Andrew as part of an interagency research project to assess and to monitor the effects of hurricanes on mangrove forests. Field surveys were slow after Hurricane Andrew because of site inaccessibility and the extensive forest damage that hindered ground movement. To overcome these logistical problems, remote videography was taken at low altitude by helicopter over mangrove forests along the southwestern coast of Florida. Coastal and inland transects were flown within the forest boundary of mangrove extent over Ten Thousand Island National Wildlife Refuge and Everglades National Park. The transects were perpendicular to the hurricane path. Continuous video footage was taken along these transects with recorded voice transmissions of coordinate location, altitude, flight speed, bearing, and other pertinent observations of ground damage on the tape. A separate Global Positioning System (GPS) unit tracked exact helicopter movement along with the video. Video analysis involved both visual and image analysis protocols to assess the degree of damage, windfall

orientation, and canopy height of the forest below. A systematic sampling approach was employed to preselect video frames for analysis and georeferencing. A geospatial modeling tool, HURASIM, was used to reconstruct wind speed and direction for each transect and freeze frame assessment to correlate forest damage and hurricane force. The results of the study demonstrate the utility of videography to capture responses that depend on time and space (i.e., site impact and recovery) and to increase the overall scale and area of assessment for large phenomena like hurricanes. Similarities and differences between the inland and coastal transects showed the general pattern of the eyetrack, where winds were highest and also showed the circulation pattern of hurricane winds. Aerial videography proved to be an efficient and timely means to document large-scale hurricane damage and may help to monitor ecosystem recovery in the coming years.

Modeling Land Elevation and Sea-Level Rise Effects on Coastal Habitat of Northwest Florida

Thomas W. Doyle, Richard H. Day, and Janelda M. Biagas, USGS, National Wetlands Research Center

Nature preserves and refuges in coastal areas of the United States are slowly being inundated by increasing sea levels. Global warming threatens to increase seawater temperatures and thereby speed the rate of sea-level rise. A cooperative research study was conducted to assess the impacts of possible climate change scenarios on the functional wetland landbase and habitat of St. Marks National Wildlife Refuge in northwest Florida. A geospatial simulation model of land elevation and species zonation has been developed to predict ecosystem response to changing sea-level conditions. The model contains functional attributes of habitat sensitivity to hydrologic conditions linked with a geographic information systems (GIS) data base of site characteristics, including habitat type, elevation, soils, and land use. The geospatial aspects of model development include multiple data layers of biological and physical descriptions of the landbase into a GIS. Land elevation and water depth are key factors controlling habitat type and distribution in this coastal environment. Map information of hypsography and bathymetry of the study area were digitized and interpolated to construct a digital elevation model. Classified thematic mapper imagery of aquatic and terrestrial habitat at a community level was used to initialize model simulation by vegetative type. Model simulations were generated to predict a likelihood index of habitat change and conversion under different scenarios of sea-level rise. Major portions of the existing refuge are predicted to be inundated by seawater that in turn will change the total area and proportion of some habitats and the wildlife they support. The approach offers a technological tool for research and policy purposes that allows for effective land and water management, risk assessment, and cumulative impact analysis of wetland systems and landscapes.

Coastal Change Analysis Implemented in Louisiana

Elijah W. Ramsey III and Gene A. Nelson, USGS, National Wetlands Research Center; Sijan K. Sapkota, Johnson Controls World Services Inc., National Wetlands Research Center; and David J. Emmons, Oak Ridge Associated Universities

Landsat Thematic Mapper images from 1990, 1993, and 1996 and collateral data sources were used to classify the land cover of the Mermentau River Basin (MRB) within the Chenier Plain of coastal Louisiana. Landcover classes followed the National Oceanic and Atmospheric Administration's Coastal Change Analysis Program definition; however, classification methods and protocols had to be developed as part of this study to be able to use these national standards. Classification method and protocol developments were especially important when classes were spectrally inseparable, when classes were part of composition and spatial continuums, when the spatial resolution of the sensor included more than one landcover type, and when human activities caused abnormal transitions in the landscape. Most classification problems were overcome by using one or a combination of techniques such as separating the MRB into subregions of communality, classifying the subregions into the major classes (e.g., water, upland, and wetland), and subsequently performing progressive classification under class masks during the refinement stage of classification.

Overall, a 78% to 86% class accuracy represented what could be expected at a per point validation at a 25-m minimum mapping unit, while nearly 98% accuracy represented dominant classes at a 75-m minimum mapping unit. Most classification errors were associated with confusion between managed and unmanaged grasslands, scrub-shrub and forests, water and floating vegetation, and water and unconsolidated shore. In total, three points (1990, 1993, and 1996) for landcover change analysis instead of two resulted in a higher classification accuracy and more detailed change analysis, and thus, more clearly exposed how each landcover type contributed to or benefited from the stability of another landcover type and how human interactions or natural forces influenced landcover transitions.

Roadside Versus Remote: Is the Habitat Sampled by the Breeding Bird Survey in Maryland Representative of Statewide Conditions?

D. Daniel Boone, APL Inc., Patuxent Wildlife Research Center; John R. Sauer, USGS, Patuxent Wildlife Research Center; and Ian L. Thomas, APL Inc., Patuxent Wildlife Research Center

The North American Breeding Bird Survey (BBS) has received criticism that the bird habitat sampled along the 24.5 mile long roadside transects may not be proportional to regional totals. If true, trends in bird populations recorded by the BBS may not be sensitive predictors of regional or continental change in songbird abundance. To test whether the approximately 60 BBS routes in Maryland representatively sample the state's habitat, a geographic information system (GIS) database was compiled of significant bird habitat identified from remotely sensed landcover and land-use information (e.g., Multi-Resolution Land Characteristics Consortium-classified Landsat Thematic Mapper imagery, etc.). These GIS data layers were analyzed to determine the statewide acreage of identified habitats as well as the acreage in each of the major physiographic regions of Maryland. Regional and statewide totals were also extracted for the subsample of habitat within 30 m of the BBS transects. The results of the comparison of regional and statewide habitat totals with the BBS sample showed very low proportional difference for nearly all of the identified habitat parameters. For Maryland and perhaps other urbanizing states, the BBS provides an accurate sample of available songbird habitats.

(The authors were given the opportunity to amend this abstract but declined to do so; NWRC editors performed routine copyediting.)

Identifying and Prioritizing Whitebark Pine (*Pinus albicaulis*) in Glacier National Park

Kristopher T. Peterson and Katherine C. Kendall, USGS, Glacier Field Station

In the last century whitebark pine (*Pinus albicaulis*) has declined precipitously due to white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), and fire suppression. Historically, fire played an important role in whitebark pine ecology by providing the proper conditions for regeneration and removing competing species. The fire return interval in these areas since effective fire suppression techniques evolved has surpassed the historic intervals that perpetuated whitebark pine. In an effort to appropriately reintroduce fire into whitebark pine communities within Glacier National Park, a multivariate geographic information system (GIS) analysis was developed which identified habitat conducive to optimal whitebark pine regeneration and growth. Habitat types were grouped into those supporting dominant seral whitebark pine and those that do not. Class signatures of the two groups were derived and applied, yielding their likely geographic distributions in forested subalpine areas (79% accuracy). This GIS coverage is reclassified to display only dominant seral whitebark habitat. Identified potential habitat was prioritized according to contiguous area, probability of occurrence, time since last fire, and relative accessibility. Approximately 87,500 acres were identified as seral whitebark pine habitat, with most of these acres being on the east side of the park. The highest priority habitat areas were first, St. Mary; second, Many Glacier; and third, Belly River subdistricts, with Muir and Park Bear Management Zones also rating as high priority.

Author Addresses

Noah Adams
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Lab
5501A Cook-Underwood Road
Cook, WA 98605-9717
509-538-2299

Thomas P. Albright
Raytheon Information Technology and Scientific Services
U.S. Geological Survey
EROS Data Center
Sioux Falls, SD 57198
605-594-6061
talbrigh@usgs.gov

Gerald Anderson
U.S. Department of Agriculture
Agricultural Research Service
Northern Plains Agricultural Research Laboratory
Sidney, MT 59270
406-433-9416
gerry@mail.sidney.ars.usda.gov

John Barras
U.S. Geological Survey
National Wetlands Research Center
Coastal Restoration Field Station
625 North Fourth St.
GIS Lab Room 317
Baton Rouge, LA 70802-5364
225-342-2077

Troy Barrilleaux
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Wylie Barrow
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Douglas S. Bateman
Department of Forest Science
Oregon State University
3200 SW Jefferson Way
Corvallis, OR 97331
541-737-7784
douglas_bateman@usgs.gov

John W. Beeman
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Lab
5501A Cook-Underwood Road
Cook, WA 98605-9717
509-538-2299
john_beeman@usgs.gov

Janelda M. Biagas
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Mark Books
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

D. Daniel Boone
APL Inc.
Patuxent Wildlife Research Center
12100 Beech Forest Road, Suite 4039
Laurel, MD 20708
301-497-5500

David A. Brandt
U.S. Geological Survey
Northern Prairie Wildlife Research Center
8711 37th Street SE
Jamestown, ND 58401
701-253-5500

Jean May-Brett
Louisiana Public Broadcasting
Baton Rouge, LA 70810
800-272-8161
jmay-brett@lpb.org

Thomas Brooks
Department of Biological Sciences and
Center for Advanced Spatial Technologies
University of Arkansas
Fayetteville, AR 72701

Karl Brown
U.S. Geological Survey
Center for Biological Informatics
Denver Federal Center
Building 810, Room 8000
Mail Stop 302
Denver, CO 80225
303-202-4220
karl_brown@usgs.gov

Arturo Calix
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Donald Catanzaro
Department of Biological Sciences and
Center for Advanced Spatial Technologies
University of Arkansas
Fayetteville, AR 72701

Paul Chadwick
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
paul_chadwick@usgs.gov

Adam Chandler
Energy and Environmental Information Resources Center
Center for Advanced Computer Studies
University of Louisiana at Lafayette
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Timothy D. Counihan
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Jennifer Coyle
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Patrick J. Crist
U.S. Geological Survey
Gap Analysis Program
530 S. Asbury Street, #1
Moscow, ID 83843
208-885-3901
pcrist@usgs.gov

Bruce Davis
National Aeronautics and Space Administration
John C. Stennis Space Center
Stennis, MS 39529-6000
228-688-2121

Richard H. Day
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Boulevard
Lafayette, LA 70506 USA
337-266-8500

Aaron J. DeLonay
U.S. Geological Survey
Columbia Environmental Research Center
4200 New Haven Road
Columbia, MO 65201
573-875-5399
aaron_delonay@usgs.gov

David C. Douglas
U.S. Geological Survey
Alaska Biological Science Center
1011 East Tudor Road
Anchorage, AK 99503
907-786-3473
david_douglas@usgs.gov

Thomas W. Doyle
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
tom_doyle@usgs.gov

Thomas A. Edsall
U.S. Geological Survey
Great Lakes Science Center
1451 Green Rd.
Ann Arbor, MI 48105
734-994-3331
thomas_edsall@usgs.gov

Wilson Eedy
Terfa Inc.
RR# 1, 11525 Town Line
Moffat, Ontario
Canada L0P 1J0
edith@netcom.ca

David J. Emmons
Oak Ridge Associated Universities
P.O. Box 117
130 Badger Ave.
Oak Ridge, TN 37831

Dan Foley
Energy and Environmental Information Resources Center
Center for Advanced Computer Studies
University of Louisiana at Lafayette
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Bonnie Foster
National Park Service
Theodore Roosevelt National Park
Medora, ND 58645
701-623-4466

Jennifer Gaines
U.S. Geological Survey
Office of Biological Informatics
12201 Sunrise Valley Drive
Reston, VA 20192
703-648-4208
jennifer_gaines@usgs.gov

Garrett Girod
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Sue Grace
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Robert E. Gresswell
U.S. Geological Survey
Forest and Rangeland Ecosystem Science Center
3200 SW Jefferson Way
Corvallis, OR 97331
541-750-7410
robert_gresswell@usgs.gov

Rob Green
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109-8099
818-354-9136
rog@jpl.nasa.gov

Denny Grossman
The Nature Conservancy
4245 N. Fairfax Drive
Arlington, VA 22207
703-841-5305
dgrossman@tnc.org

James Guyton
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Aladdin Hafez
Energy and Environmental Information Resources Center
Center for Advanced Computer Studies
University of Louisiana at Lafayette
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506

Steve Hager
National Park Service
Theodore Roosevelt National Park
Medora, ND 58645
701-623-4466 ext. 3433
steve_hager@nps.gov

Jill M. Hardiman
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Tom Hargis
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Boulevard
Lafayette, LA 70506
337-266-8500

Lawrence R. Handley
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
larry_handley@usgs.gov

Nathanial S. Handley
University of Louisiana at Lafayette
National Aeronautics and Space Administration
Regional Application Center
Lafayette, LA 70506

Steve Hartley
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
steve_hartley@usgs.gov

Susan Haseltine
U.S. Geological Survey
12201 Sunrise Valley Dr.
Restoin, VA 20192
703-648-4060

Glen S. Holmberg
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Philip N. Hooge
U.S. Geological Survey
Alaska Biological Science Center
Glacier Bay Field Station
Gustavus, AK 99826
907-697-2637
philip_hooge@usgs.gov

Robert B. Jacobson
U.S. Geological Survey
Columbia Environmental Research Center
4200 New Haven Road
Columbia, MO 65201
573-875-5399

Clinton W. Jeske
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
clint_jeske@usgs.gov

Darren Johnson
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

James B. Johnston
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

William R. Jones
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
william_jones@usgs.gov

Kevin M. Kappenman
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Katherine C. Kendall
U.S. Geological Survey
Glacier Field Station
West Glacier, MT 59936

Gregory W. Kennedy
U.S. Geological Survey
Great Lakes Science Center
1451 Green Rd.
Ann Arbor, MI 48105
734-994-3331
gregory_kennedy@usgs.gov

Eileen Kirsch
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, WI 54603
608-753-6451
eileen_kirsh@usgs.gov

Steve Knick
U.S. Geological Survey
Forest and Rangeland Ecosystem Science Center
Snake River Field Station
970 Lusk Street
Boise, ID 83705
208-426-5200

Erik Kofoot
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Carl Korschegen
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
LaCrosse, WI 54603
608-753-6451

Kurt P. Kowalski
U.S. Geological Survey
Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105-2807
734-994-3331

Gary L. Krapu
U.S. Geological Survey
Northern Prairie Wildlife Research Center
8711 37th Street SE
Jamestown, ND 58401
701-253-5500
gary_krapu @usgs.gov

Ken Krauss
U.S. Department of Agriculture
Pacific Southwest Research Station
Institute of Pacific Islands Forestry
1151 Punchbowl St., Room 323
Honolulu, HI 96813

Samuel Lammie
Voyageurs National Park
3131 Highway 53
International Falls, MN 56649
218-283-9821
sam_lammie@nps.gov

Diane Larson
U.S. Geological Survey
Northern Prairie Wildlife Research Center
Minnesota Field Station
University of Minnesota
100 Ecology Building
1987 Upper Buford Circle
St. Paul, MN 55108
612-624-6777
dlarson@biosci.umn.edu

Mark S. Laustrup
U.S. Geological Survey
Columbia Environmental Research Center
4200 New Haven Road
Columbia, MO 65201
573-875-5399

George Lienkaemper
U.S. Geological Survey
Forest and Rangeland Ecosystem Science Center
3200 SW Jefferson Way
Corvallis, OR 97331
541-750-7307
george_lienkaemper@usgs.gov

W. Fredrick Limp
Department of Biological Sciences and
Center for Advanced Spatial Technologies
University of Arkansas
Fayetteville, AR 72701

Edward E. Little
U.S. Geological Survey
Columbia Environmental Research Center
4200 New Haven Road
Columbia, MO 65201
573-875-5399

Catherine Lockwood
Chadron State College
1000 Main Street
Chadron, NE 69337
308-432-6275
clockwood@csc.edu

Tom Loveland
U.S. Geological Survey
EROS Data Center
Sioux Falls, SD 57198
605-594-6066
loveland@usgs.gov

John W. McCoy
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
john_mccoy@usgs.gov

Laurie Marien
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Antonio Martucci
Johnson Controls World Services Inc.
U.S. Geolgical Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Thomas C. Michot
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Richard B. Minnis
Mississippi State University
Mississippi Cooperative Fish and Wildlife Research Unit
Department of Wildlife and Fisheries
Mississippi State, MS 39762
601-325-3158

Dave Morton
U.S. Geological Survey
Aquatic Ecology Laboratory
Leetown Science Center
1700 Leetown Road
Kearneysville, WV 25430
304-724-4460

Rosemary Mouton
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Gene A. Nelson
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Robert A. Norheim
U.S. Geological Survey
Forest and Rangeland Ecosystem Science Center
Cascadia Field Station
University of Washington
College of Forest Resources
Seattle, WA 98195-2100
206-543-9138
norheim@u.washington.edu

Wayne Norling
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
wayne_norling@usgs.gov

Maury Nyquist
U.S. Geological Survey
Center for Biological Informatics
Denver Federal Center, Building 810
P.O. Box 25046
Denver, CO 80225
maury_nyquist@usgs.gov
303-202-4220

Michael O'Neill
University of California Davis
Center for Spatial Technologies and Remote Sensing
Davis, CA 95616
530-752-5092

Keith Ouchley
The Nature Conservancy of Louisiana
P.O. Box 4125
Baton Rouge, LA 70821

Kelby Ouchley
U.S. Fish and Wildlife Service
Louisiana Wetlands Management District
Rocky Branch, LA 71241

Thomas Owens
U.S. Geological Survey
Center for Biological Informatics
Denver Federal Center
P.O. Box 25046, MS 304
Denver, CO 80225
303-202-4220
tom_owens@usgs.gov

Charles Palmer
Texas Water Development Board, TNRIS
P.O. Box 13231
Austin, TX 78711-3231
512-463-8402
cpalmer@twdb.state.tx.us

Michael J. Parsley
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299
michael_parsley@usgs.gov

Kristopher T. Peterson
U.S. Geological Survey
Glacier Field Station
West Glacier, MT 59936
406-888-7988
kris_t_peterson@usgs.gov

Matt Phillips
Johnson Controls World Services Inc.
Barataria-Terrebonne National Estuary Program
Nicholls State University Campus
Thibodaux, LA 70310

Charles F. Rabeni
U.S. Geological Survey
Missouri Cooperative Fish and Wildlife Research Unit
University of Missouri
112 Stephens Hall
Columbia, MO 65211

Elijah W. Ramsey III
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
elijah_ramsey@usgs.gov

K. Jon Ranson
National Aeronautics and Space Administration
Goddard Space Flight Center
Biospheric Sciences Branch Code 923
Greenbely, MD 20771
301-614-6650
jon.ranson@gsfc.nasa.gov

Robert E. Reagan
U. S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Wayne G. Rohde
U.S. Geological Survey
EROS Data Center
Sioux Falls, SD 57198
605-594-6126
rohde@usgs.gov

Dennis W. Rondorf
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299
dennis_rondorf@usgs.gov

Ralph Root
U.S. Geological Survey
Center for Biological Informatics
Denver Federal Center
Denver, CO 80225-0046
303-202-4220
ralph_root@usgs.gov

Brett Rubenstein*
U.S. Geological Survey
Northern Prairie Wildlife Research Center
Minnesota Field Station
University of Minnesota
100 Ecology Building
1987 Upper Buford Circle
St. Paul, MN 55108

*Current address:
Camp Thunderbird, Inc.
967 Gardenview Office Pkwy. #1
St. Louis, MO 63141

David E. Rupp
U.S. Geological Survey
Western Fisheries Research Center Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Sijan K. Sapkota
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

John R. Sauer
U.S. Geological Survey
Patuxent Wildlife Research Center
12100 Beech Forest Road, Suite 4039
Laurel, MD 20708
301-497-5500

Eric Seeger
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

George Scheer
University of California Davis
Center for Spatial Technologies and Remote Sensing
Davis, CA 95616
530-752-5092

Robin M. Schrock
U. S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Linda Schueck
Boise State University
Raptor Research Center
1910 University Avenue
Boise, ID 83725
208-426-3353
lschueck@email.boisestate.edu

Charles C. Schwartz
Grizzly Bear Study Team
U.S. Geological Survey
Midcontinent Ecological Science Center
Greater Yellowstone Field Station
Montana State University
c/o Forestry Sciences Lab
Bozeman, MT 59717
406-994-5043
ccs@montana.edu

Mindi B. Sheer
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Kimberly G. Smith
Department of Biological Sciences and
Center for Advanced Spatial Technologies
University of Arkansas
Fayetteville, AR 72701
501-575-3251
kgsmith@comp.uark.edu

Craig Snyder
U.S. Geological Survey
Leetown Science Center
1700 Leetown Road
Kearneysville, WV 25430
304-724-4469

Elizabeth K. Solomon
U.S. Geological Survey
Alaska Biological Science Center
1011 East Tudor Road
Anchorage, AK 99503
907-786-3512

Susan Stitt
U.S. Geological Survey
Center for Biological Informatics
Denver Federal Center, Building 810
P.O. Box 25046
Denver, CO 80225
303-202-4220
susan_stitt@usgs.gov

James Taulman
Department of Biological Sciences and
Center for Advanced Spatial Technologies
University of Arkansas
Fayetteville, AR 72701

Jesse Thibodeaux II
Johnson Controls World Services Inc.
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Ian Thomas
APL Inc.
U.S. Geological Survey
Patuxent Wildlife Research Center
12100 Beech Forest Road, Suite 4039
Laurel, MD 20708
301-497-5500
ian_thomas@usgs.gov

Nissa M. Thomsen
U.S. Geological Survey
Leetown Science Center
Aquatic Ecology Laboratory
1700 Leetown Rd.
Kearneysville, WV 25430
304-724-4460

Larry L. Tieszen
U.S. Geological Survey
EROS Data Center
Sioux Falls, SD 57198
605-594-6056
tieszen@usgs.gov

Susan Ustin
University of California Davis
Center for Spatial Technologies and Remote Sensing
Davis, CA 95616
530-752-5092
susan@vache.ucdavis.edu

Francisco J. Vilella
Mississippi Cooperative Fish and Wildlife Research Unit
Department of Wildlife and Fisheries
Mississippi State, MS 39762

Jan van Wagtendonk
U.S. Geological Survey
Yosemite Research Center
El Portal, CA 95318
209-379-1885
jan_van_wagtendonk@usgs.gov

Rachel E. Wardell
U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501A Cook-Underwood Road
Cook, WA 98605
509-538-2299

Christopher Wells
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500

Douglas A. Wilcox
U.S. Geological Survey
Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105-2807
734-994-3331

Andrew C. Wilson
Burke and Mayer
Energy Center
1100 Poydras Street
New Orleans, LA 70163
awilson@burke-mayer.com

Barry Wilson
Gulf Coast Joint Venture
c/o U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
barry_wilson@usgs.gov

Wayne Wiltz
U.S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506
337-266-8500
wayne_wiltz@usgs.gov

John Young
U.S. Geological Survey
Leetown Science Center
1700 Leetown Road
Kearneysville, WV 25430
304-724-4469
john_a_young@usgs.gov

Tom Zarriello
U.S. Geological Survey
Forest and Rangeland Ecosystem Science Center
Snake River Field Station
970 Lusk Street
Boise, ID 83705
208-426-5200
tom_zarriello@usgs.gov

Acknowledgments

We would like to express our appreciation to the following people for their assistance in putting the symposium and proceedings together: Gaye Farris, Sue Lauritzen, Natalie Trahan, Rhonda Davis, Beth Vairin, Calvin O'Neil, Arturo Calix, Eric Seeger, Kelly Mouton, Tom Owens, Linda Leake, John Young, Mike Parsley, Ralph Root, and Karl Brown. For their sponsorship and support, we wish to thank Sue Haseltine, Gladys Cotter, Larry Ludke, Tom Casadevall, Robert Stewart, Jr., and James Johnston.

Conversion Table

Multiply	By	To Obtain
acres	0.4047	hectares
hectares (ha)	2.471	acres
square miles (mi^2)	2.590	square kilometers
square kilometers (km^2)	0.3861	square miles
feet (ft)	0.3048	meters
meters (m)	3.281	feet
square feet (ft^2)	0.0929	square meters
square meters (m^2)	10.76	square feet
inches	2.54	centimeters
centimeters (cm)	0.3937	inches

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USGS-National Wetlands Research Center
Technology & Informatics Branch

Chief
Gaye S. Farris

Production Staff

Editors Tammy M. Charron, (Johnson Controls World Services)
Rhonda F. Davis
Beth A. Vairin

Layout/Cover design Natalie G. Trahan, (Johnson Controls World Services)
Printing Liaison Susan M. Lauritzen

U.S. Department of the Interior
U.S. Geological Survey

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